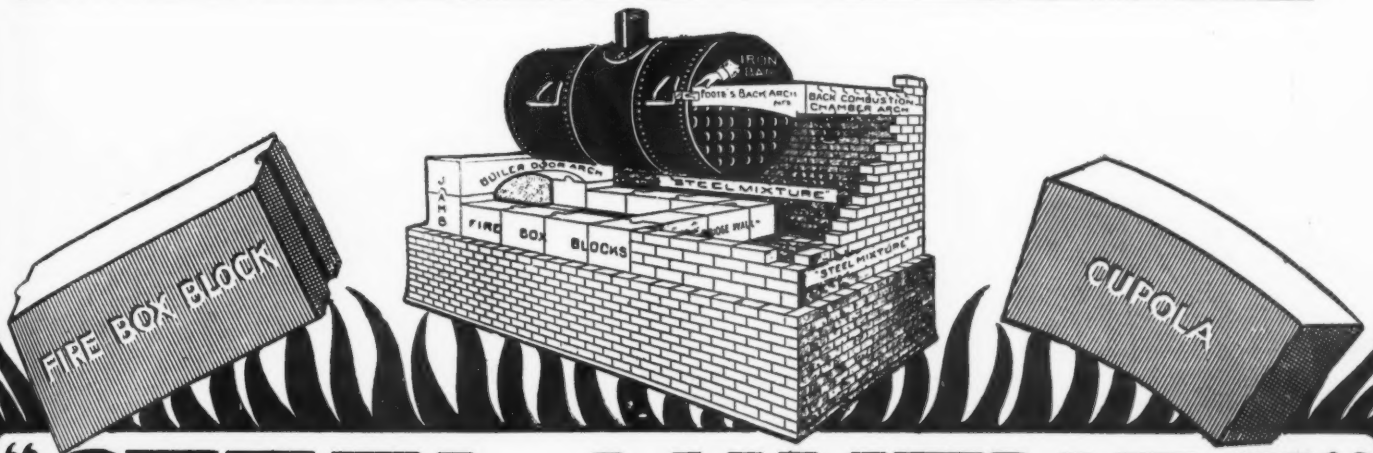
$2.00 per Year NOVEMBER 10, 1908. Price 5 Cents.

POWER AND THE ENGINEER

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY, 505 PEARL STREET, NEW YORK.

Vol. 29. Index to Advertisers and Classified Index Following Reading Matter No. 19.



"STEEL MIXTURE"

Boiler Door Arches, Fire Box Blocks, and Back Combustion Chamber Arches

which comprise our boiler setting are easy to install anywhere, and far more durable than any others on the market. For hard service they are unapproached, as "Steel Mixture" does not fuse under 4000° F.

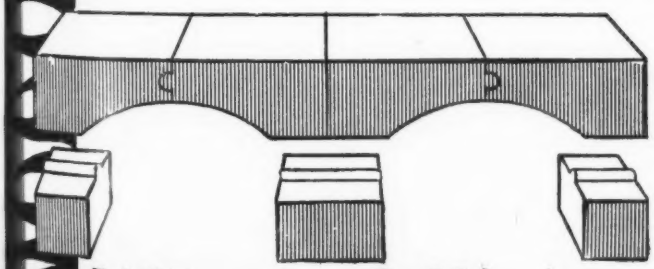
Our Boiler Door Arches take the place of built up arches and jambs. The jambs are one solid, smooth piece the full height of the door.

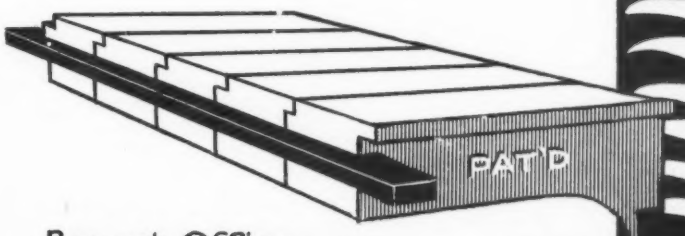
The Fire Box Blocks present a smooth, practically unbroken surface to the action of the fire and reduce the joints 75%.

The Back Combustion Chamber Arches, made of special "Steel Mixture" blocks are the simplest, most highly efficient, most durable known

Let us give you full particulars. Write for Dimension Booklet.

3000 USERS





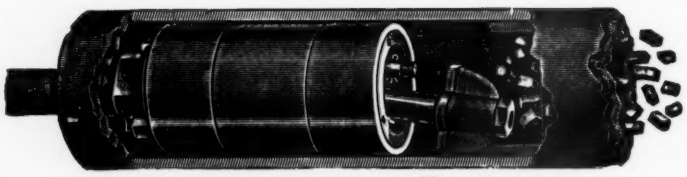
McLeod & Henry Co., Branch Office, 1402 Broadway, New York City Troy, N.Y.

Mr. Engineer, Some Day The Boss Is Going To Come Around

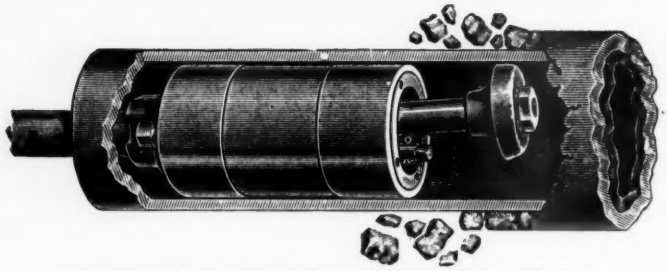
and ask you some such questions as these: "Why are you using more coal, for the same amount of steam, than you did when the boilers were new?" "How do you account for the pitting and corrosion of tubes?" "What's the matter with that tube cleaner you have—it has cost us more for repairs the past year than the price we paid for the tool?" "I want RESULTS and I want RESULTS at the smallest cost," he will add.

Then, maybe, you'll remember what we have been telling you about

THE DEAN BOILER TUBE CLEANER



Removing Scale from the Tube of a Water Tube Boiler.



Removing Scale from the Tube of a Return Tubular Boiler.

—the cleaner that cleans the tubes clean.

—the cleaner that is built so strong and on such simple principles that it will outlast any three cleaners of other makes.

—the cleaner that removes soot and scale in the same operation.

—the cleaner that wins in competitive tests.

Engineers come around to our way of fighting scale sooner or later. We don't care what they start out using. 10,000 engineers know why the DEAN furnishes the easiest, quickest, most thorough method of removing scale from either side of the tubes. The rest will follow just so sure as scale removal continues to be a problem.

Why not start NOW? You don't have to purchase until you've satisfied yourself about the merits of the tool. We'll loan you one, free of charge, for a thorough test on one boiler.

Write for booklet, "From Water To Steam."

The WM. B. PIERCE COMPANY

JEWETT BUILDING
BUFFALO, N. Y.

LONDON OFFICE
13-15 Wilson Street
Finsbury, London, E. C.

NEW YORK OFFICE
20 New Street
Tel. 5120 Rector

CHICAGO OFFICE
1001 Monadnock Building
Chicago, Ill.

Have You Seen The FREE OFFER Of The KEYSTONE LUBRICATING COMPANY?

A LARGE CAN OF KEYSTONE GREASE, A FINE BRASS GREASE CUP AND AN ENGINEER'S COLLAPSIBLE LUNCH BOX sent express paid and absolutely free to engineers who want to know the wonderful value of

KEYSTONE GREASE

Simply fill out and mail to us the attached coupon and the three articles will be started your way at once. We will be fully repaid if you will give Keystone Grease a fair test on your engines or auxiliaries.

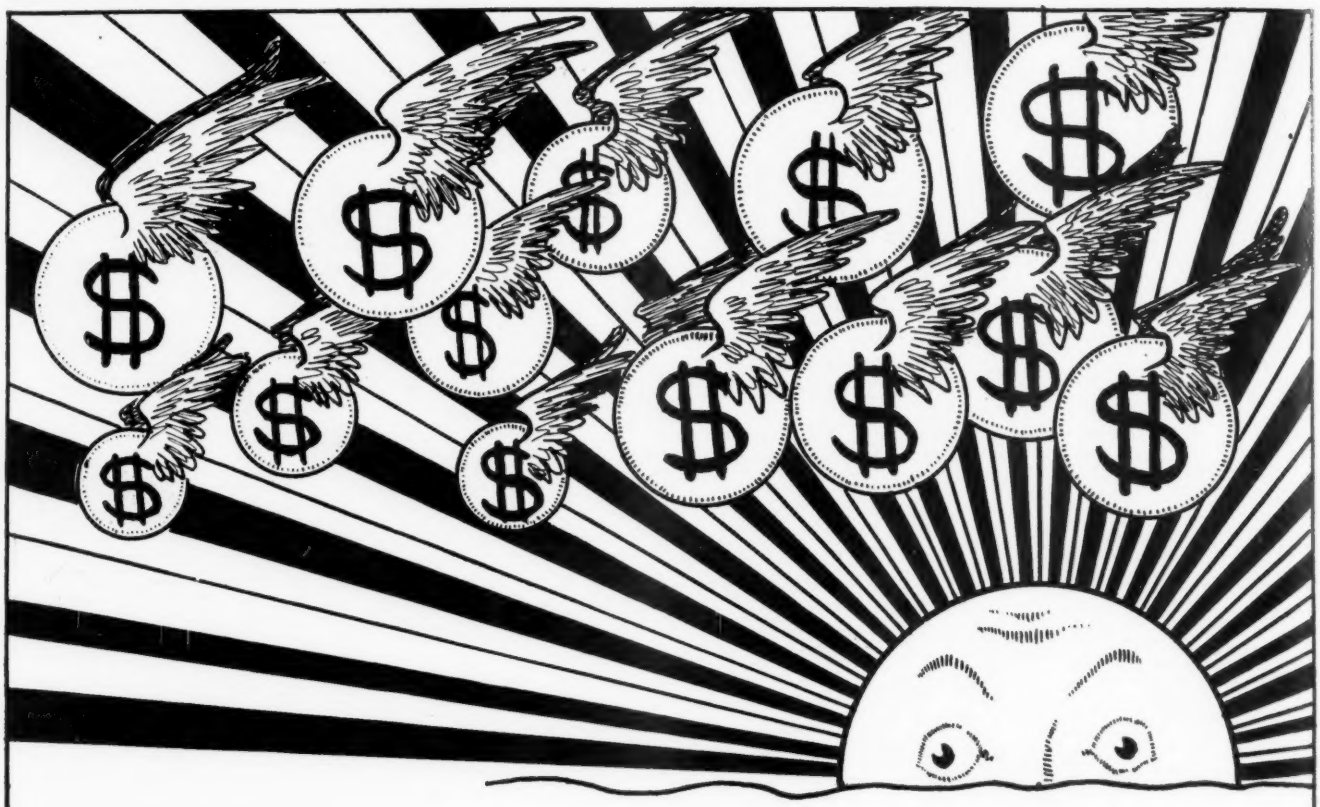
Don't delay. Write us today.

See Our Advertisement On Inside Back Cover

KEYSTONE LUBRICATING CO.,
Dept. B. PHILADELPHIA, PA.

New England Office—10 Oliver St., Boston, Mass.
New York City Office—96 Warren St.
Southern Office—610 Chartres St., New Orleans, La.
Northwestern Office and Warehouse—502 McPhee Bldg., Denver, Col.
San Francisco Office and Warehouse—268 Market St., San Francisco, Cal.
Chicago Office—1210 Tacoma Bldg

Name.....
Name of Firm.....
.....
Address in Full.....
.....
.....
H. P. of Engine.....
On what bearing will sample be tested?
.....
Its width.....
R.P.M.....
Size of tap for cup.....
Nov. 10.-08, Dept. B



My, how dollars fly!
Especially for cheap sheet packing!
You know how it is yourself.
How can you keep your dollars?
That's easy! Awfully easy!
Just use the dollar saving

EBONITE BLACK SHEET PACKING

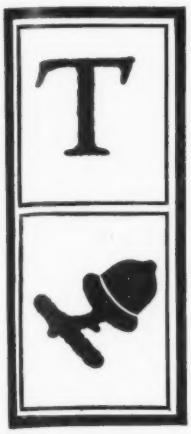
Try it for a year—in superheated steam joints, high steam, etc.—any joint, in fact—and then count the dollars it has enabled you to hold on to. Oh! you'll hug yourself and wonder why you didn't try EBONITE before.

Now, don't get confused about the name and accept something that sounds like "EBONITE." If you want a higher quality at a lesser final cost, you want EBONITE. Nothing else in the world will do for you.

QUAKER CITY RUBBER CO.,

PHILADELPHIA PITTSBURGH CHICAGO

The House of Dearborn



THERE is always one great pioneer and leader in the development of every important industry. Twenty years ago, the fact that great savings could be made in fuel consumption and that boilers and boiler tubes could be made to last much longer, but for the detrimental action of boiler feed waters, interested some young chemists in Chicago in the possibility of surmounting this difficulty by making careful analytical study of different classes of waters, and finding scientific reagents for the elements that produced the trouble.

Thus began the work of the DEARBORN COMPANY. That it has been successful is attested by the fact that thousands of steam plants use their products, prepared according to analysis of the waters, and find absolute relief from the troubles formerly experienced.

With its large corps of representatives, all of whom are *mechanical experts*, working in all sections of the country, backed by the scientific laboratory work done at Chicago, the Dearborn Company is able to give personal attention to every case, making careful study of the water and plant conditions and furnishing treatment that exactly meets requirements.

DEARBORN DRUG & CHEMICAL WORKS

ROBERT F. CARR, President.

W. B. McVICKER, Vice-Pres. & Gen. Mgr. | GEORGE R. CARR, Vice-Pres. | G. W. SPEAR, Vice-Pres.
W. A. CONVERSE, Asst. Sec. & Chem. Dir. | J. D. PURCELL, Asst. Gen. Mgr. | H. R. BROWNING, Asst. Treas.

POSTAL TELEGRAPH BLDG., CHICAGO. 299 BROADWAY, NEW YORK.

BRANCH OFFICES

Philadelphia, The Bourse
Detroit, Majestic Building
Denver, Majestic Building
Boston, Oliver Building
Birmingham, First Nat. Bank Bldg.
Salt Lake City, Dooly Block
Pittsburg, House Building
St. Louis, Security Building
San Francisco, 301 Front Street
Buffalo, Morgan Building
Kansas City, New York Life Building
Milwaukee
Cleveland
Los Angeles, 325 E. Second Street
Cincinnati, Union Trust Building
St. Paul, 1237 Lincoln Avenue
Honolulu, 42 Queen Street
Havana, Esquina Mercaderes y Cortina de Valdes
Indianapolis
Peoria, Mayer Building

You'll Always Be Able To Tell By The Label

SMOOTH-ON
TRADE MARK-REG. U.S. PAT. OFF.
Coated Corrugated
GASKET
Ready for use.

SMOOTH-ON
TRADE MARK-REG. U.S. PAT. OFF.
Coated Corrugated
GASKET
Ready for use.

SMOOTH-ON
TRADE MARK-REG. U.S. PAT. OFF.
Coated Corrugated
GASKET
Ready for use.

SMOOTH-ON
TRADE MARK-REG. U.S. PAT. OFF.
Coated Corrugated
GASKET
Ready for use.

whether your dealer is giving you the GENUINE Smooth-On Gasket, or some spurious imitation.

We have placed this label on Smooth-On Gaskets for *your protection*. Smooth-On Gaskets are being imitated by an article which has nothing in its favor. So hand the dealer back his lemon, if he offers you a "just-as-good."

The genuine Smooth-On Gaskets are coated with Smooth-On Elastic Iron Cement. This coating expands and contracts the same as iron, guaranteeing permanently tight joints under severe conditions.

WRITE FOR BOOK.

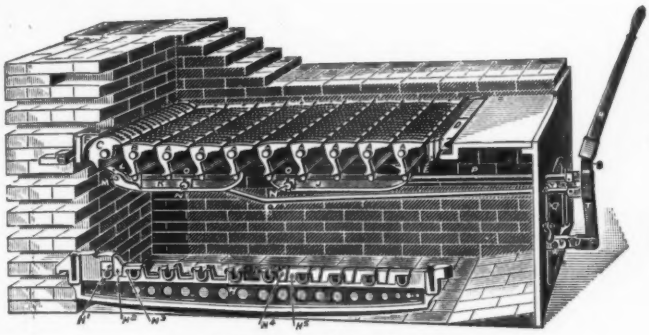
Smooth-On Manufacturing Company

JERSEY CITY, N. J., U. S. A.

Chicago Warehouse
61 N. JEFFERSON STREET

English Branch
8 WHITE ST., MOORFIELDS, LONDON, E. C.

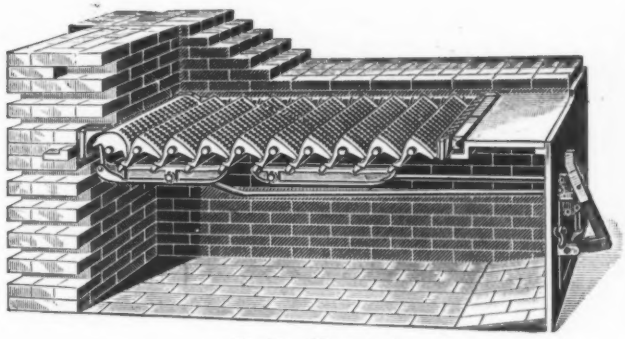
San Francisco Warehouse
94 MARKET STREET



Normal Position of Grate

Don't Buy Costly Coal

On McClave Grates you can use cheapest fuels, such as anthracite birdseye, bituminous slack, screenings, duff, etc., with as good results as other grates obtain from high priced coal.

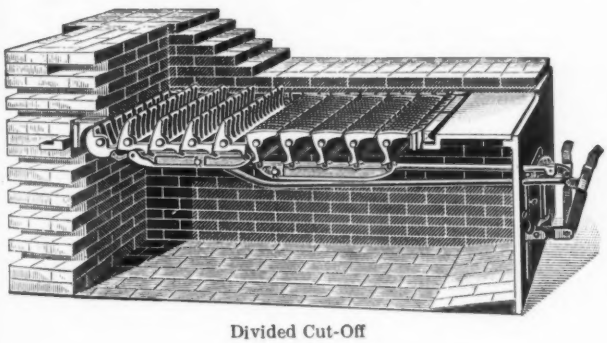


Shaking Movement

McClave Grates

Argand Steam Blower

Argand Blowers



Divided Cut-Off

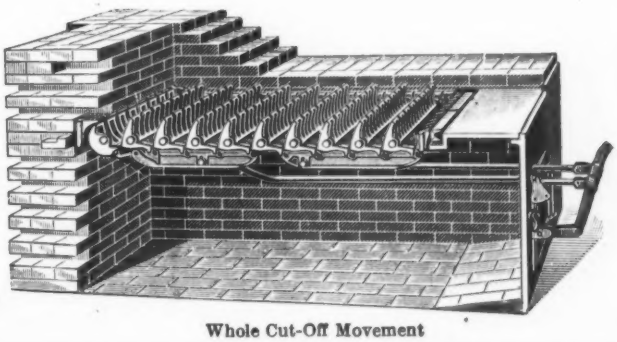
Fires can be cleaned uniformly from front to rear without opening doors; two cut-off movements provide for removing clinkers of various sizes; the Argand Blower supplies a mixture of air and steam that compels complete and rapid combustion. The other features are equally important.

Write today for Catalog "G".

McClave-Brooks Co.

Scranton, Pa.

BRANCH OFFICES: Charles N. Hays, Sales Agent, Fisher Building, Chicago; Empire Building, Pittsburg.



Whole Cut-Off Movement

IT HAS "MADE GOOD"

TRADE PENBERTHY MARK.

AUTOMATIC INJECTORS

are known in every country in the world, and wherever sent they have given satisfaction.

When properly connected—you open the steam valve and the injector does the rest.

They are so simple they can be operated by a novice.

The last **450,000** Injectors sent out are identical in construction, therefore by sending for any part, an engineer can repair his Injector whether in the United States or South Africa.

No engineer can afford to equip his boiler with *any* Injector because it is cheap.

Every Injector guaranteed to be as represented.

TRADE PENBERTHY MARK. **XL-96 EJECTOR**

FOR LIQUID ELEVATING OR SYPHON PURPOSES.

Send for circular describing its many uses.

Send for "Engineer and Fireman," an 80-page journal, FREE on application, devoted to items of interest to engineers.

"Engineer and Fireman" 80-page magazine, Subscription Agents Wanted, 30% Commission on 50-cent Subscription Price. Write for particulars.

PENBERTHY INJECTOR COMPANY

DETROIT, MICHIGAN, U. S. A.

Branches, New York City and London, Eng. **Canadian Factory, Windsor, Ontario.**

SAY!

IT IS

GARLOCK PACKING

WHAT APPEALS TO AN ENGINEER MORE

THAN A PACKING THAT CAN BE PLACED AND THEN FORGOTTEN? THAT IS THE WAY YOU CAN DO

WITH

GARLOCK FIBROUS or PITT METAL PACKINGS

25 YEARS' MANUFACTURING EXPERIENCE
HIGH GRADE MATERIALS
PERFECT WORKMANSHIP

—THOSE ARE SOME OF THE REASONS

THE GARLOCK PACKING COMPANY

Main Offices and Factory - - - - - PALMYRA, N. Y.

BRANCH STORES AND OFFICES:

PHILADELPHIA	604 Arch Street
SAN FRANCISCO	670 Howard Street
NEW ORLEANS	200 Decatur Street
BIRMINGHAM, ALA	2221 Morris Avenue
ELLWOOD CITY	Pennsylvania
NEW YORK	136 Liberty Street
PITTSBURG	100-108 Smithfield Street
CLEVELAND	1536 Columbus Road, N. W.
KANSAS CITY	206 Kemper Building
BALTIMORE	Continental Trust Building
NORFOLK	Bank of Commerce Building
CHICAGO	115 South Franklin Street
BOSTON	43 High Street
ST. LOUIS	109 North 8th. Street
DENVER	1609 Glenarm Street
DETROIT	1305 Majestic Building
BUFFALO	534 Ellicott Square
CINCINNATI	St. Paul Building
SALT LAKE CITY	Utah
LOS ANGELES	California
PORTLAND	Oregon
SEATTLE	Washington

BRANCH FACTORIES:

SAN FRANCISCO . NEW ORLEANS HAMBURG, Germany DENVER ELLWOOD CITY, PA.

FILTERING PLANT IN THE MOUNT VERNON STATION OF THE PHILADELPHIA RAPID TRANSIT CO.

Four More "Units"!
Thirty In Three Years!!

For The Philadelphia Rapid Transit Co.

Three years ago the above company installed six "Unit" Filters as an experiment. Since then they have repeatedly added more until now there are thirty at work in their plant.

It's not advertising, nor salesmanship, nor claims that have sold those "Units"—it's satisfactory results. That's obvious.

And what the "Unit" is doing in Philadelphia, it will do in Denver or Kalamazoo—or wherever *your* plant is.

The "Unit" is guaranteed to clean, purify and filter thin or heavy oil and return it in perfect condition. Install one—or as many as you need—and, when the need for more arises, they can be added, connected up and any number operated as one.

Unit Filters save 50 to 90% of the oil—and each "Unit" delivers clean and pure 200 to 250 gallons every 24 hours.

Send for our new 96-page Catalog.

THE BURT MFG. CO., 232 Main St., Akron, O., U.S.A.

Largest Manufacturers of Oil Filters in the World.

The Practical Operation of Reducing Wheels

Constructive Features and Operating Details of Wheels in Common Use, with Some General Instruction on Reducing Wheels in General

BY HUBERT E. COLLINS

Reducing motions of the lever type and pantographs were among the first apparatus used in reducing the motion of engine crossheads to a proportion suitable for the indicator. In modern practice, however, the wheel type of reducing motion has been largely adopted, as it possesses many advantages over the older types. The first and principal advantage is their adaptability to all strokes of engines. The lever motion has several parts which are hard to adjust to suit different strokes. Against this defect of the lever motion, the wheel motions now made have the advantage of being provided with many different-sized bushings on one of the pulleys to vary the proportion to suit the varying stroke. All reducing motions have some defects, and the reducing wheels have their quota, but no more than others.

Before giving general rules which apply to all reducing wheels, we will take up in detail an explanation of all the parts of certain makes of wheel, the functions they perform and any special instructions necessary to handle or operate them properly.

A Reducing Motion with Helical Spring

Fig. 1 illustrates a Crosby reducing wheel with the indicator mounted in place. The reducing motion is entirely distinct from the indicator, and terminates at the bottom with a swivel joint by which it is attached to the indicator cock. On top, the arm of the reducing motion is finished to receive the swivel joint of the indicator itself, which is attached, as shown in the figure, in such a position that the cord pulley of the indicator drum is directly over the small sheave about which the cord from the paper barrel is passed. Fig. 2 shows this position to better advantage. The principal object sought and attained by this design and arrangement of reducing wheel and indicator is rigidity. As the wheel or its frame does not depend from the indicator proper, the strength of the combination is good. The pull of the crosshead is resisted and the cord is returned by the helical spring *A*, Fig. 3, contained in the horizontal spring case *B*. Adjustment of this spring is made by the milled head which closes the outer end of the case and carries one end of the spring. This head slips over the squared end of the horizontal shaft *D*, and is secured in place by the thumb screw *E*. The shaft is carried on ball bearings *F* and *G* in the frame *H*, and the web and gear *I* of the small sheave are a part of the horizontal shaft. On this small sheave are the bush

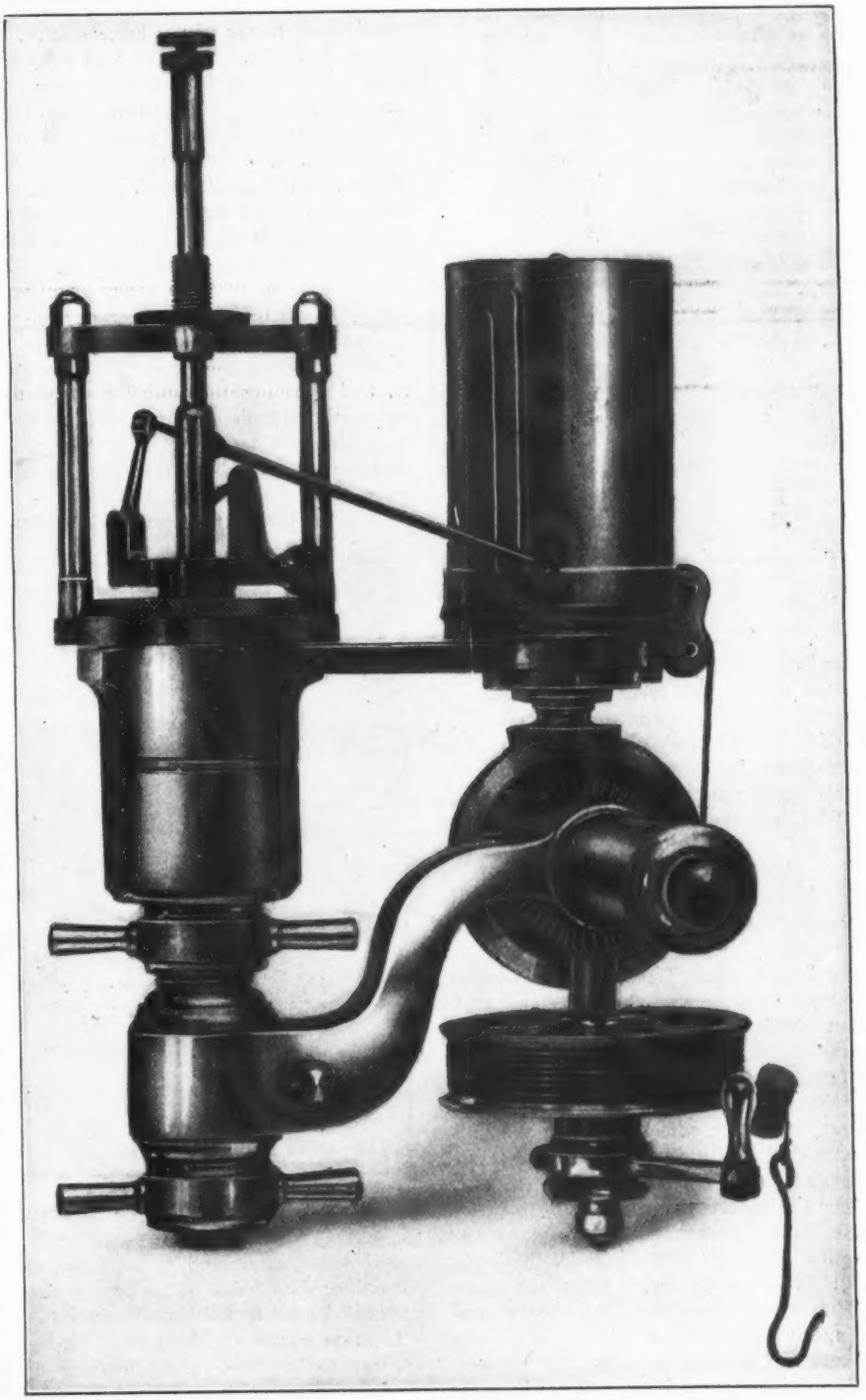


FIG. 1. CROSBY INDICATOR AND REDUCING MOTION ASSEMBLED

ings *J* which are taken off or added to, to get the proper ratio of motion for the paper drum. The bushings are held in place by a flange *K* and thumb screw *L*.

The main frame *H* is a casting, and from it depends the vertical shaft *M*, upon which revolves the sleeve *N* carrying the smaller of the bevel gears and the

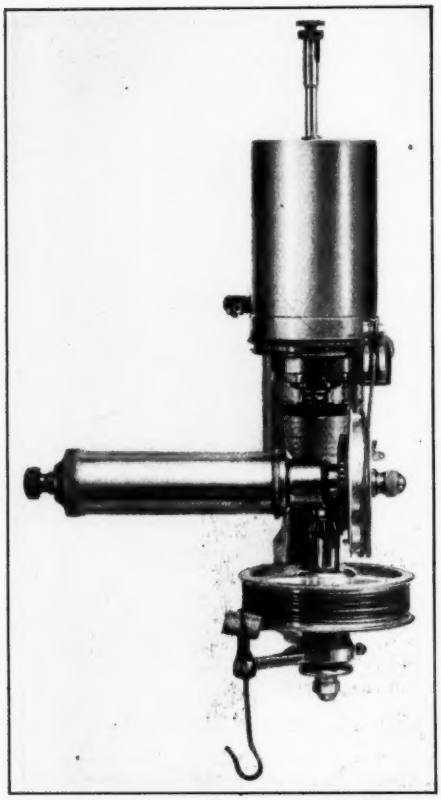


FIG. 2. CORD CONNECTION FROM DRUM TO REDUCING WHEEL

cord-receiving sheave *O*. Beneath the large sheave and turning therewith is a screw engaging with the crosshead *P* which carries the cord guide *Q*. The crosshead is prevented from turning by two guide pins *R* and *S*, upon which it slides, and these pins are supported by a plate *T* at the bottom of the vertical shaft. This plate is secured by an hexagonal nut *U*. The arm carrying the cord guide is clamped around the crosshead, and may be turned to lead in any direction. Above the bottom plate *T* is a stiff four-leaved spring *V* to receive the crosshead without shock in case it is allowed to run way down, as it would by the breakage of the cord.

When ready to use the reducing motion, first mount the wheel frame on the indicator cock and the indicator on the frame, as shown in Figs. 1 and 2. Then, after determining the size of bushing to go on the small sheave, put it in place and secure it under the flange *K* with the nut *L*. Pass the cord from the paper drum once around the small sheave, slipping the end through the hole in the flange and securing it to the cleat thereon. Be sure that there is enough cord on the large sheave to accommodate the longest engine stroke for which the wheel will be used. Then pass the end through the guide pulley *Q* and there fasten it to resist the tension of the spring, leaving enough more cord to reach the crosshead of the engine. The crosshead *P* of the reducing motion must be just low enough for the guide pulley to lead the cord from the bottom flange of the large sheave, as shown in Fig. 1. Then the cord from the paper drum must be brought down and around the small sheave to the hole in the flange, so that while the motion is at rest, as in Fig. 1, it will pass around the sheave, in the direction of its travel, far enough to pass over the circumference of the bushing on the sheave. Before fastening to the cleat, the cord must be drawn taut, so that the paper drum will have just left its rest stop.

To alter the tension on the recoil spring of this reducing motion, remove the nut *E*, and grasping the milled head *C* between the thumb and forefinger, pull it from the case far enough to allow it to be turned. Then twist it to the right, if more tension is desired, and allow it to slide onto the square end of the horizontal shaft again and replace the nut. To reduce the tension of the spring, allow the milled head to fall back to the left.

If at any time the horizontal shaft *D* appears to be loose in its bearings and needs adjustment, remove nut *E*, grasp the head *W* in the fingers and back it off from its place. This will carry the spring, case and milled head from their positions and expose the adjustment *X* and its lock nut *Y*. Back off the lock nut and adjust the bearings with the other nut, after which lock the two nuts together again. Always try the bearings again after setting up on the lock nut.

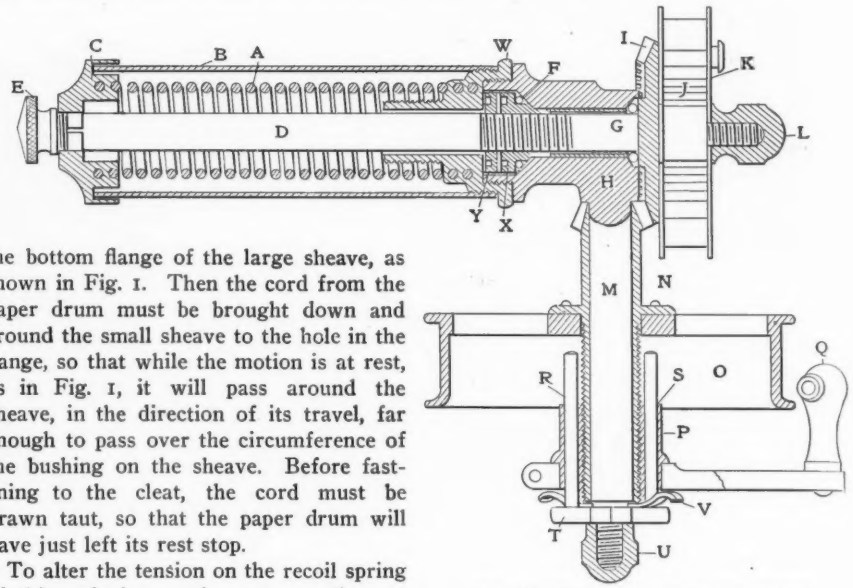


FIG. 3. SECTIONAL VIEW OF CROSBY REDUCING MOTION

Clock-spring Type of Wheel

The type of wheel just explained is the special product of one manufacturer, but the general type illustrated in Fig. 4 is made by several manufacturers. While this particular wheel, which was made by the Trill Indicator Company, gives the principal features of several makes of reducing wheel, it has several features in the nature of improvements which make it one of the most advanced types

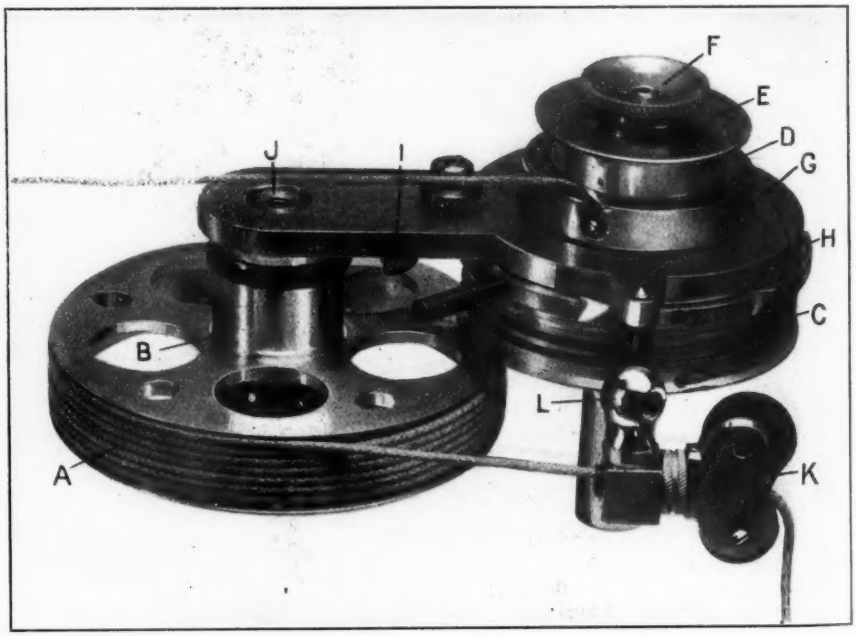


FIG. 4. TRILL REDUCING WHEEL

on the market. The largest pulley *A* is the receiving or cord pulley, which takes the cord from the crosshead or other point from which the motion is derived. The small pulley *B* on the same spindle has a diametrical ratio to the large one of 4 to 1, and transmits the motion to the second largest pulley *C*, which also forms the spring case for the instrument. On the same spindle is a nest of bushings *D* from which the right size is chosen to give the proper proportion of stroke to the paper barrel of the indicator for any given piston stroke. There are eight of these bushings, held in place by the flange *E* and nut *F*, which make the instrument adjustable to as many engine strokes, and by a change in receiving pulleys the instrument is adjustable to eight more strokes. The casting which secures the bushings is notched on its edge, as shown in Fig. 4, to receive the end of the cord from the paper barrel. The notches are an improvement over the notch and cleat or the hole in the flange used on some wheels, for with the end of the cord knotted and inserted in one of these notches, it is out of the way.

Inside the pulley *C* is a spring of the clock type. One end of this spring is secured to the inside of the pulley rim and the other end to the stationary spindle in the center. In the flange *G* is a series of holes into which the pawl *H* fits. Notches are also placed in this flange to hold the ratchet at *I*. By inserting the pawl in the holes the flange can be turned in either direction to add to or decrease the tension of the spring.

To attach the wheel to an indicator, remove the cord pulley from the indicator, and on the same spindle under the paper drum, screw the hollow spindle *J* of the wheel until it is in place. Then bring the cord from the paper barrel around the pulley *D* and secure the knotted end in one of the notches shown.

With the wheel arranged as in Fig. 4, eight different strokes, from the longest down, are provided for. For strokes shorter than this range, detach the cord connecting pulleys *B* and *C*, change the cord pulley *K* to the stud *L* and lead the cord from pulley *C* direct to the crosshead.

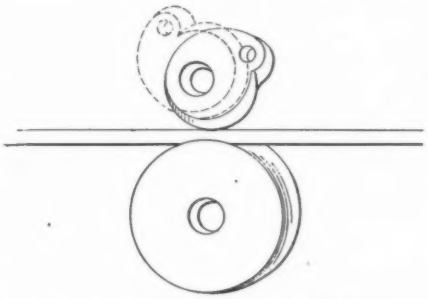


FIG. 5. CAM CLUTCH TO HOLD CORD

In this type of wheel another feature of special interest is the cam clutch in the cord-pulley frame. This clutch holds the cord when the wheel is out of service, and is shown in detail in Fig. 5. When it is desired to hold the cord, turn the cam down in the position shown in the full lines. When it is desired to release the cord, throw the cam to the position shown by the dotted lines.

Attaching Reducing Wheels

Reducing wheels of the type shown in Fig. 4 are most commonly used, and to fasten them to the indicator frame, first remove the usual guide pulley from the indicator and in its place attach the reducing wheel. The arrangement of the complete outfit is shown in Fig. 6. The cord from the large pulley to the crosshead must pull in a straight line—not necessarily in the manner shown in the figure (although this is the most desirable arrangement), but at any rate the cord must run parallel to the piston rod.

Sometimes it is necessary to lead the cord through one or two guide pulleys in addition to the one on the reducing wheel in order to bring it in line with the point of attachment to the crosshead. The arrangement shown in Fig. 6 can be used only when the indicator is attached to the side of the cylinder, and in order to run the cord parallel to the piston rod the standard *A* must be secured to the crosshead and the cord hooked to it. At times a stud can be screwed into the crosshead which will reach out beyond the side line of the cylinder frame far enough to attach the cord, and a small offset will bring it in line. In many cases a straight pull cannot be secured without the aid of one or two additional guide pulleys fastened somewhere on the frame. In this case a straight pull should be obtained with the fewest pulleys. Another important condition to look out for is to see that there are no knots or obstructions in the cord between the reducing wheel and the last pulley wheel, for, if there are, they will cause a jump in the cord when passing over the pulley.

Keeping these facts in mind, proceed to hook up the wheel to the indicator and crosshead. Mount the indicator, with the wheel attached, on the indicator cock, and then attach the cord from the indicator drum to the bushing pulley of the wheel. First ascertain which way the paper drum

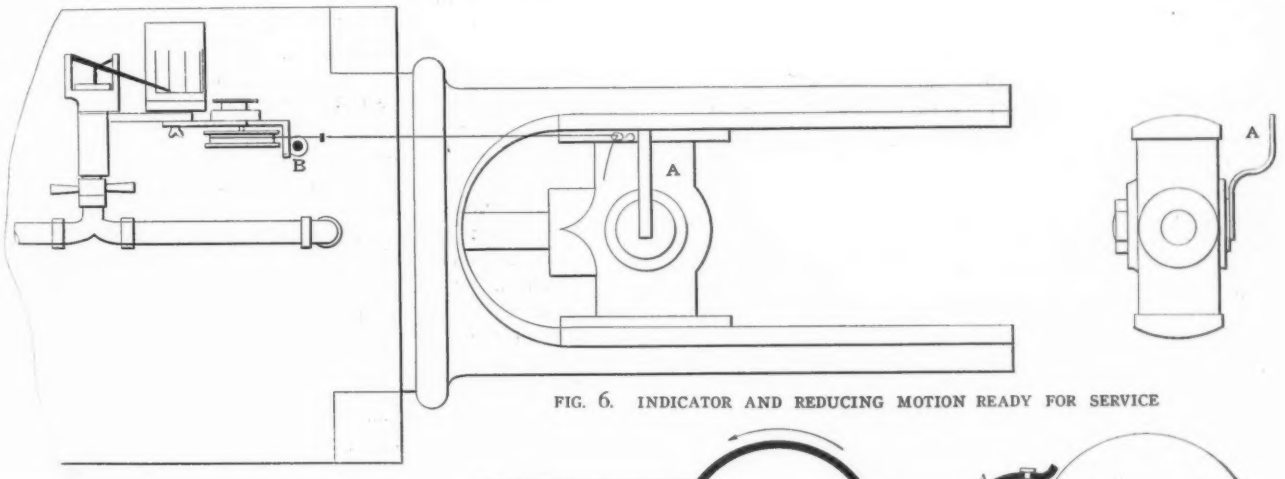


FIG. 6. INDICATOR AND REDUCING MOTION READY FOR SERVICE

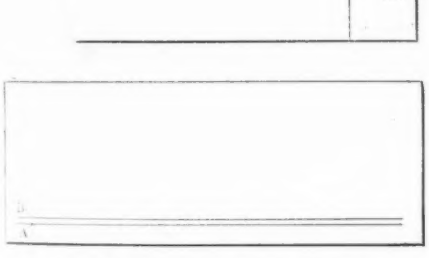


FIG. 8. TESTING RECOIL SPRING

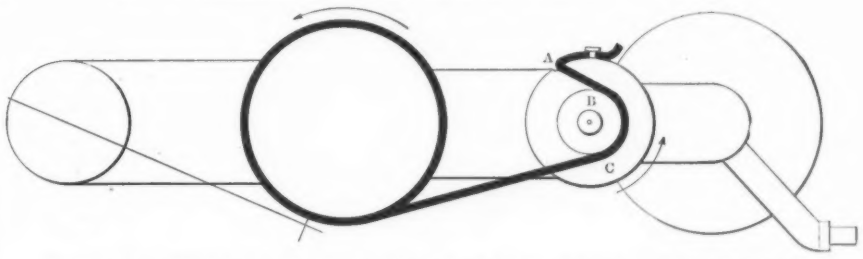


FIG. 7. OUTLINE PLAN OF INDICATOR-DRUM AND WHEEL ARRANGEMENT

travels in starting up, and see that the cord is placed around it one full turn; then note by trial how the bushing wheel on the reducing motion travels, and pull the cord around in the direction of travel until the notch or hole in the edge of the lower flange is reached, and fasten it there. If a hole is provided, secure the cord by tying a knot at the end, or if there is a notch in the flange and a cleat on the side, draw the cord through the notch and tie to the cleat, using a knot or half hitch. Fig. 7 is an outline plan of the indicator paper drum and wheel arrangement showing how the cord should be brought around and fastened. Always draw the cord in the direction of travel of the drum and wheel. When the wheel is at rest, the notch *A* may not be in the relative position shown, and if it should be at *C*, for illustration, the cord would need to be passed once around the wheel in the direction of travel before making the end fast. This cord should be drawn taut enough to just hold the paper drum from its stop, when the wheel is at rest.

Now proceed to hook up the cord from the large wheel to the crosshead. Use a stiff, light hook on the end of this cord. When the wheel and indicator are at rest, pull the engine over to the head center, and then pull the hook out until it touches the standard *A*, Fig. 6. Fasten the cord to the hook by a knot or hitch. Turn the engine to the crank center and draw the cord out by the hook as far as it will go, to see if the hook will pass the standard by a small amount without first bringing the paper drum up to its back stop. If the right size of bushing has been placed at *B*, Fig. 7, the hook on the cord will go just far enough and draw the cord out just enough to have the paper drum not quite touch the stop. If the bushing is too small, the hook will pass the standard at the crank end a considerable distance. If too large, the hook will not reach the standard.

A new cord may stretch after a few revolutions and allow the drum to strike on the return stroke. A readjustment of the length must then be made. Too much tension on the recoil spring will create friction, and not enough tension will result in a defective diagram. To test the recoil spring for weakness, attach the cord to the crosshead, and with a card on the paper drum, draw the line *A*, Fig. 8, on the card while the engine is turning over slowly; then draw the line *B* by raising the pencil slightly, with the engine at full speed. If *B* is shorter than *A* to any appreciable extent, the recoil spring is weak.

It is announced that the Electrical Review Publishing Company, of New York, publisher of the *Electrical Review*, has purchased the *Western Electrician*, of Chicago, and the two papers will be consolidated. The publication offices will be at Chicago.

Capacity of Cylindrical Tanks

By N. A. Carle

Tables are published showing the capacity in gallons of cylindrical tanks of various diameters per foot of depth. These are convenient either for ascertaining the capacity in gallons in a tank when the diameter and length are known, or for ascertaining the diameter when the length and capacity in gallons are known, or for ascertaining the length when the diameter and capacity in gallons are known. In making these calculations the tabulated value for any diameter per foot of length must be multiplied by the length and, conversely, when the capacity in gallons is known, it must be divided by the length to get the value which will be tabulated for the diameter per foot of length.

It is frequently desirable to know the diameter and length of a tank having a capacity equal to a tank of a different diameter and length. This is ascertained by getting the value from the tables corresponding to the given diameter for a tank one foot in depth and multiplying this value by the length to obtain the capacity of the tank in gallons. Dividing the value for the capacity of the tank by any value selected for the length of a tank of equal capacity will give a result which will be the tabulated value of the diameter corresponding to the length selected.

Tanks used in power houses for storing oil or water are usually open at the top and have a diameter from 1 to 2 times the hight; pressure tanks, for steam, air or water under pressure, usually have a length of from 2 to 6 times the diameter.

The chart on page 773 is designed to show graphically the dimensions of tanks having capacities up to 5000 gallons. The left half side of the chart has a range which is intended for open-top tanks from 4 feet to 12 feet 6 inches in diameter and hights up to 7 feet 6 inches. The right-hand half of the chart is intended to apply to pressure tanks from 2 feet to 6 feet 3 inches in diameter and up to 30 feet long. This arrangement is merely a matter of convenience, as these sizes cover most of the tanks used in power houses; either half may be used for either open top or pressure tanks, of course, if the dimensions of the tank agree with the sizes on the chart. In calculating the capacity of pressure tanks, no allowance is made for the hemispherical heads which usually have a radius equal to the diameter of the tank. The length of the tank is taken as the actual length of the barrel.

Examples

What is the capacity in gallons of an open-top tank 10 feet in diameter and 6 feet high?

Starting with 6 feet hight of tank, read up to 10 feet diameter of tank and across to approximately 3525 gallons.

What will be the length of a tank to hold 2250 gallons, if the diameter is 4 feet 9 inches?

Starting with 2250 gallons, read across on the right side of the chart to 4 feet 9 inches and then down to approximately 17 feet.

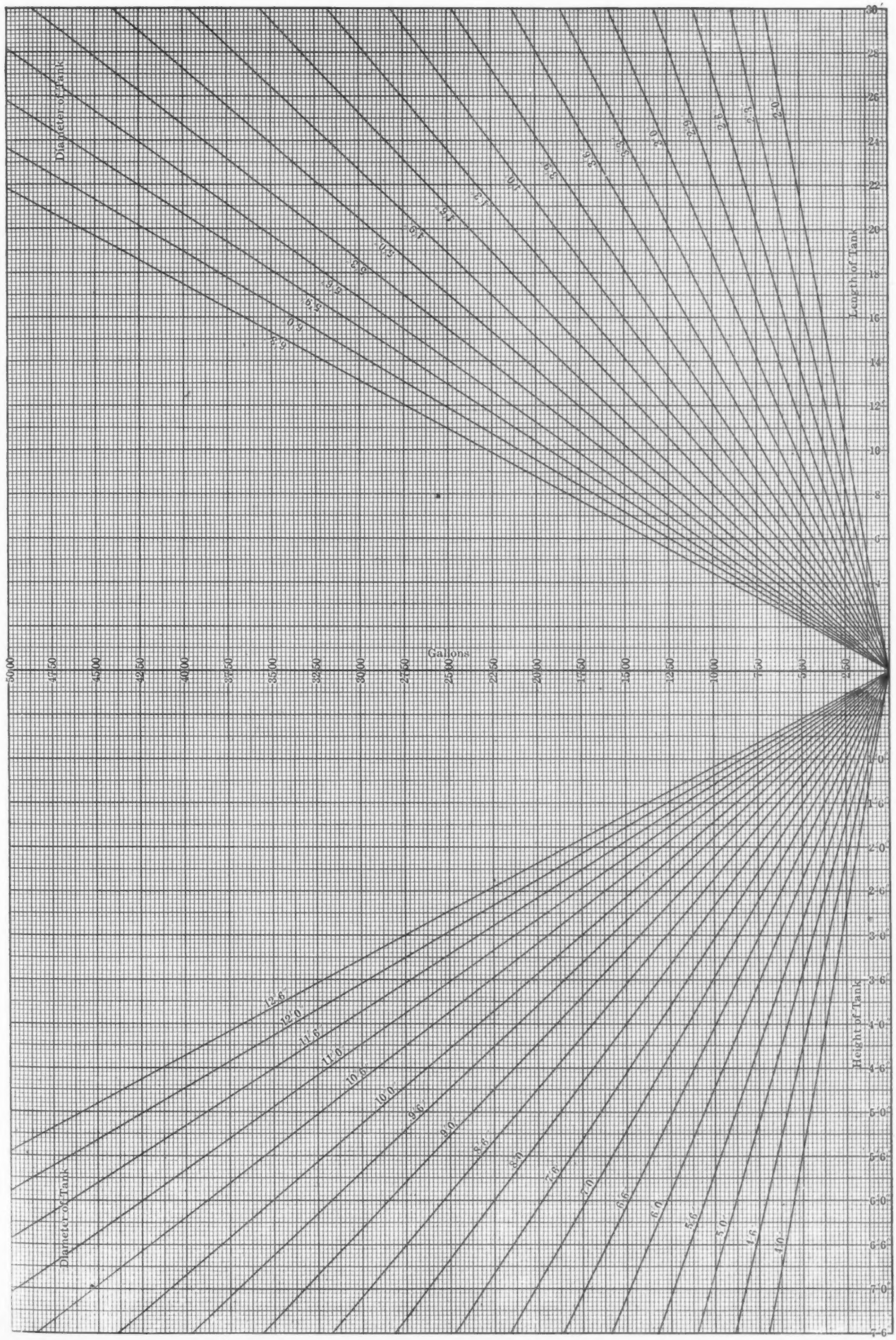
What length of tank 4 feet 6 inches in diameter has a capacity equal to a tank 9 feet in diameter and 7 feet high?

Starting with 7 feet hight of tank, read up to 9 feet diameter of tank, then across to 4 feet 6 iniches diameter of tank and then down to 28 feet length of tank. In reading across the chart it may be noted that the capacity of the tank is approximately 3325 gallons.

The Theoretical and the Practica

By F. L. Johnson

I sat watching a sort of dissolving view of the man going to the elevator, who had just given me a bad half hour in explaining his particular regenerative engine and turbine set and expressing his amazement at the appalling depths of my ignorance of what he termed the fundamentals of thermodynamic science. He had a gas producer, a gas engine, a countercurrent feed-water heater, a compressor, a turbine and a closed tank. In operation, in his mind, the exhaust from the gas engine passed through the feed-water heater converting into steam water which was pumped through it in the opposite direction because it was a countercurrent heater. The steam from the heater, being of low pressure, was taken by the compressor, compressed to a high pressure and delivered to the closed tank from whence it was drawn to operate the turbine, the water of condensation from the turbine being sent to the feed-water heater to be again made into steam. Electric current was generated for power or lighting purposes by the turbine, and the power of the gas engine not needed to operate the compressor, circulating pumps and exciter was to be used in the same way, running in parallel with the generator on the turbine. Questioned as to how steam of a low pressure was to be compressed to a pressure sufficiently high to be of any use in the turbine, he explained that steam of atmospheric pressure was all that was needed, provided that the temperature was high enough, as it was the heat that did the work, and the act of compressing would create the necessary heat. I was of the opinion that if steam was compressed, instead of rising in temperature to any extent it would be apt to turn to water, and as water was non-compressible, little or no heat would be added by pressure. In this it seems I was mistaken, for steam would not condense, he said, unless heat was taken from it; in this case heat was being added by compression, and once being steam no



SHOWING DIMENSIONS OF TANKS HAVING CAPACITIES UP TO 5000 GALLONS

pressure would reduce it to water unless it gave up some of the heat.

I got lost in the labyrinths of his reasoning and frankly told him that I did not think any gain above the original power of the gas engine was to be made by the introduction into the system of the feed-water heater and turbine. More in anger than sorrow he said:

"Young man! Years before you were born a steamship was designed for transatlantic trade. Professors of natural science proved beyond a shadow of a doubt, on paper, that it was impossible for a vessel to hold coal enough to drive it across the ocean. But the vessel was built, loaded with coal and cargo and the voyage begun. Upon unloading the cargo in New York, it was discovered that it contained a consignment of the pamphlets which were written to prove that a ship could not cross the ocean under steam. It shall be the same in this case—the first work that my machine does will be to drive the press which prints the arguments of my adversaries and such fellows as you."

With that he rolled up his drawings and entropy tables and took his leave. Then the office boy handed me the card of Thomas Sawyer. Thomas was at once admitted and as I shook hands with my young friend from the chicken farm my thoughts ran away to the pine-clad hills and green fields that were then so far away from us, both in time and distance.

"Why have you stayed away so long?" I asked, as he took the proffered chair.

"I have been away most of the time since my last call on you. New York is the place to visit about twice a year and to live away from the rest of the time. The short time I spent in and near the city while looking for a location satisfied me that as long as I had quit the engine room for the sake of a little freedom and for the opportunity of spending a part of my waking hours in the sunlight, it would not be the best thing in the world to get into the game again where competition was as sharp as it is in and about the metropolis, where I must either live shut out from sufficient light and air for good health, or spend hours of valuable time every day automatically packing myself like an intelligent sardine in subway and suburban trains, losing all the good of my spare time and my respect for the rights of others. To cut it short, I went back to New Hampshire pure air and sunshine. I shall live there in the future, visiting steam plants occasionally as a sort of a reminder of my old life and its bondage.

"On my way down here this time I visited a steam plant near where I changed from train to boat. It furnished power and light to a summer amusement resort, and the peak of the load was a high one. Talking with the engineer, I learned that boiler capacity was a little shy for the maximum load of about 3600 indicated horsepower, there being only 1600 horsepower of boilers. It being near the time for the evening load to go on, I accepted the engineer's invitation to watch his method of handling a short-time overload.

"We went to the boiler room, where the real work of carrying the overload was to be done, and as we sat in front of the long row of hand-fired boilers I watched the procedure. During the lighter work of the afternoon all of the fires had been cleaned and the men were building deep fire beds in every boiler. One man would open a fire door, look the fire over and spread a few shovelfuls of coal where it was needed, and then another door was opened and the operation repeated until four boilers had been attended to. As the door closed on the fourth boiler, another man started in on the fifth and went through the same operation on his four boilers, and so on down the line until all twelve boilers were coaled. Then No. 1 started in again and the process was repeated two or three times. The head fireman looked after the water, and I noticed that he had speeded up the pump and the water was gradually rising in all of the gage glasses.

"Soon a gong sounded, which the engineer told me was the signal that the load was coming. Three men left their seats, where they had been awaiting this signal, and with long, steel slice bars raised the bed of coal from the grates of three of the boilers. As the fires were broken open I saw a bed of incandescent coke more than a foot thick at every door. Green coal had been fired into the furnaces just as fast as, but no faster, than it would coke. Soon the engines, one after another, were started and the damper, which had been closed for the greater part of the time, opened and the gong sounded again signaling that the load was all on. The men at once broke up the remaining fires. The needles of the steam gages trembled and dropped back about two pounds on the dial, stopped, and then slowly moved ahead until the damper closed. The speed of the feed pumps was not changed, but water, which had been carried to the highest safe limit, slowly settled in the gage glasses, and the engineer told me that about the time the water reached the lower gage cock the load would begin to drop off and the boilers would fill.

"The run was started with the boilers full of water as hot as the steam being made and a little over two gages of water in each boiler that did not have to be heated from 180 to 350 degrees during the time when the heaviest draft was being made on the boilers. As the damper opened and closed the men alternately broke open and coaled the fires—and such fires I never saw before, deep, dazzlingly white and blinding to look at, and thick, almost touching the boiler shell, but every part alive and glowing.

"The men interested me as much as the fires. There seemed to be an air of knowledge and mastership in every move. It seemed that they felt the almost impossible task that was theirs, but knew that they could accomplish it. There was no hurry, and no loafing or conversation, but for about an hour those men, with streaming faces, tense muscles and heaving breasts, worked, every movement directed by intelligence and the certainty of the final result, as I never saw men work before. As I watched them, I realized in a small measure, very small to be sure, how little the value of a good fireman is appreciated and how ridiculously he is underpaid. I thought of a thousand other things, too, about boiler rooms that I could not tell of in a week. Twice during the hour the safety valves on two of the boilers puffed lightly between the strokes of the engines, but this was promptly checked, for it was realized that although there was steam enough for the work to be done, there was none to be wasted.

"At the end of about an hour the load began to go off and the hand dampers on part of the boilers were closed. The daily battle had been won. I had seen expert firemen doing expert firing, not for the utilization of the last heat unit in the fuel, but firing against odds for the purpose of getting there; and as I walked up into the engine room with the engineer, I said to him:

"'I do not know as I shall ever twist a throttle again, but if I do, I know of one fireman that I shall try to get.'"

Society of Naval Architects and Marine Engineers

The sixteenth general meeting of the Society of Naval Architects and Marine Engineers will be held in assembly room No. 1, Engineering Societies building, New York City, Thursday and Friday, November 19 and 20. Sessions will begin at 10 a.m. each day.

There will be a banquet in Delmonico's large hall at 7 p.m. Friday, November 20, to which all members and their guests are cordially invited; tickets are $5 each.

The council will meet at 3 p.m. Wednesday, November 18, in the council room, No. 716 (seventh floor), Engineering Societies building.

Proposals for membership should be mailed so as to reach the secretary on or before November 18; blank forms of application will be furnished by the secretary when requested. The secretary is William J. Baxter, 29 West Thirty-ninth street, New York.

The forty-fourth year of the Massachusetts Institute of Technology began on September 30.

Flow of Water in Pipes and Flumes

Drop in Pressure in Water Pipes and Mains Due to Friction, with Practical Charts for Determining the Size of Pipe for Given Flow

BY FRANKLIN VAN WINKLE

The extensive use made of pipes for delivering and discharging water for all domestic, manufacturing and municipal purposes, renders the subject of flow through pipes one of wider practical interest to engineers than any other branch of hydraulics. The average engineer who looks to literature for guidance in estimating the size of pipe required for a given flow, will find himself lured into a labyrinth of formulas, square and cube roots, coefficients and tables, from which he will emerge with doubts whether to rely on his first guess or abandon the subject to some less timid guesser. The hypotheses which constitute the foundation of all discussions of the resistance to the flow of water have been wrought into varied and elegant formulas by philosophers and hydraulic engineers who have scientifically investigated the subject. But it is to be regretted that most of the authors have been unable to resist the temptation to display mathematical ingenuity, at the expense of placing the results of their labors in such practical form as to be serviceable to the busy engineer.

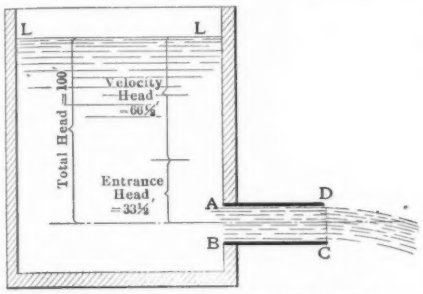


FIG. 1. CIRCULAR APERTURE WITH AJUTAGE

It is the present purpose to briefly review the leading principles which control the flow through pipes, and to present charts for practical use, by means of which the engineer can compare at sight the capacities of flow of different commercial sizes of pipe under all conditions liable to be met in practice, and with equal convenience determine upon the most economical sizes for his purposes.

A common form of expression intended to convey some idea of a rate of flow is: "Enough water to fill a 6-inch pipe." Such expressions are meaningless and misleading, unless accompanied by statements both of the head which creates the velocity of flow and the length of pipe which is assumed to be "filled." With a given head, the greatest possible discharge through a given size of pipe will take place when the pipe is only long enough for formation of a vacuum, and then the head must, of course, be sufficient to keep the pipe filled. This maximum discharge through the pipe occurs when its length is only two or three times its diameter. The flow then becomes 81 to 82 per cent. of the theoretical discharge due to the head, and for purposes of this discussion is assumed to be 81.5 per cent.

Divisions of Total Head

Suppose Fig. 1 to represent a tank or reservoir kept filled to the level *L L*, having in one side a circular aperture of diameter *A B*, extended by the ajutage *A B C D*, 2½ to 3 times the diameter of the aperture, and that a total head of 100 feet acts on the center of the

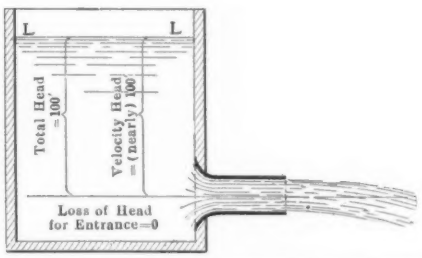


FIG. 2. BELL-SHAPED APERTURE TO REDUCE ENTRANCE-HEAD LOSS

aperture. The theoretical velocity in feet per second due to this head will be*

$$v = \sqrt{2 \times 32.2 \times 100} = 80.25$$

feet per second. The aperture *A B* being provided with an ajutage of such length that the flow completely fills the ajutage, the velocity and discharge will both be 81.5 per cent. of the theoretical velocity and discharge due to 100 feet head; i.e., 81.5 per cent. of the theoretical velocity, 80.25 feet per second, equals 65.4 feet per second, will be the actual velocity. By the formula

$$h = \frac{v^2}{2g}$$

the head required to produce this velocity is found to be

$$h = \frac{65.4 \times 65.4}{2 \times 32.2} = 66.5$$

feet. Therefore the total head required for discharge through a short, cylindrical tube may be regarded as consisting of two parts, viz., 66⅔ per cent. for generating velocity, and the balance, or 33⅓ per cent., as acting in the form of pressure to overcome the resistance of entry of the jet into the tube. The loss of entrance head may be reduced nearly to zero by employment of a bell-shaped aperture at the entrance, as shown in Fig. 2. But when the velocity and entrance heads constitute a small part of the total head required, as in long pipe lines having low velocities of flow, the advantage of a bell-shaped entrance aperture becomes inappreciable.

Any obstruction to the free discharge of a short tube results in reduction of the discharge the same as though the head itself were reduced. For instance, if a tube such as is shown in Fig. 1, instead of discharging into the atmosphere with the head above the center of the tube, discharges into another vessel, as shown in Fig. 3, against the counterhead *G* above the center of the entrance, then the net head creating the discharge will be *J*, i.e., the difference between the heads *H* and *G*, in which case with an ordinary entrance aperture, 33⅓ per cent. of *J* will be required for the entrance head and 66⅔ per cent. of the remaining head is utilized for creating velocity.

Increasing the length of the short tube shown in Fig. 1 introduces resistances which retard the flow in the same manner as though the head itself were reduced by requiring discharge to take place against a counterhead like *G* in Fig. 3. Thus the addition of the length of pipe

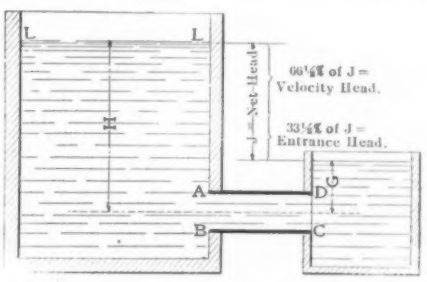


FIG. 3. DISCHARGING AGAINST COUNTERHEAD

C D E F, as in Fig. 4, may create resistance to flow equal to the counterhead *G* in Fig. 3, in which case the velocity of flow would be the same as though the discharge took place against an actual counterhead.

The resistance which pipe lines present is generally referred to as "loss of head

*See POWER AND THE ENGINEER, Aug. 25. 1908, p. 314.

in friction." This loss of head is usually large, and in long pipe lines it becomes so great that the head J, Fig. 3, remaining for entrance and velocity, is so much diminished that the velocity is reduced to only a small percentage of the velocity due to the total head.

Nature of Pipe Line Resistance to Flow

The earlier philosophers attributed the resistance to flow in pipes to adhesion of liquid particles to the walls of the pipe and also to overcoming the cohesiveness of particles of water which were separated by the roughness of the pipe wall, in these respects following the phenomena which are apparent when one solid body rubs upon another. When solid materials are rubbed together, the mechanical displacement of their particles is mainly confined to the adjoining surfaces of the bodies. But any mechanical disturbance of a liquid is indefinitely extended through the whole body of the liquid, so that in addition to overcoming adhesion to the pipe surface and cohesion of particles, flow of the liquid over the roughness of the pipe surface gives rise to innumerable deflections which are productive of eddies and countercurrents, reacting to retard the flow. The resistance which was called "loss from friction" in a water pipe is, in fact, mainly due to the impact of particles of water upon each other. This regurgitating action takes place to greater or less extent in flow through pipes of all kinds, and is illustrated by Fig. 5, which may be considered to represent the roughness of an ordinary pipe surface greatly magnified. The surfaces of many kinds of pipe may seem quite smooth to the naked eye, but a magnifying glass reveals the fact that their surfaces are composed of innumerable cavities and projections, and no illustration is adequate to convey an idea of the myriads of particles of water which, during flow, are deflected by a single one of these irregularities of the pipe surface.

Overcoming all of the resistances requires a portion of the total head which is additional to those portions of head required for entrance and for velocity of the flow, and although the resistance to flow may not, strictly speaking, be directly resultant of friction, the additional head thus required is designated "loss of head due to friction."

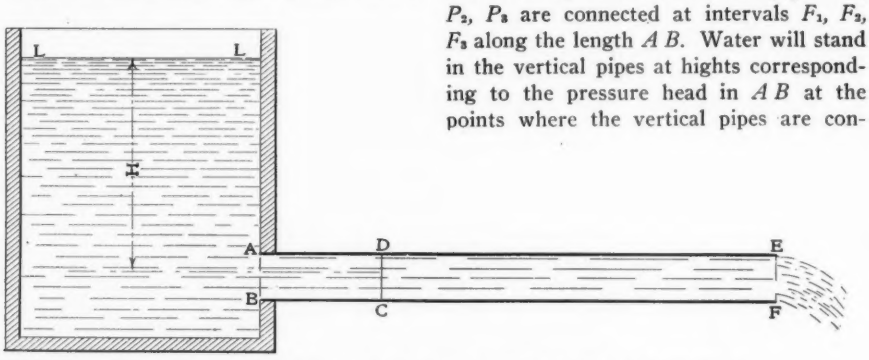


FIG. 4. ADDITIONAL LENGTH OF PIPE CAUSES RESISTANCE TO FLOW

Measuring Loss of Head Due to Friction

In Fig. 6, suppose $A\,B$ to represent a main pipe of uniform section and material, arranged to discharge water from the reservoir $R\,R$ which is kept filled to the level L, and the vertical pipes P_1, P_2, P_3 are connected at intervals F_1, F_2, F_3 along the length $A\,B$. Water will stand in the vertical pipes at hights corresponding to the pressure head in $A\,B$ at the points where the vertical pipes are connected. If a tight plug is inserted in the discharge end B of the main pipe, water will rise in each vertical pipe to the same level L_1, L_2, L_3 as the level L in the reservoir.

Upon withdrawing the plug from B there will be a relief of pressure all along the main, causing the water in each of the vertical pipes to fall to the levels H_1, H_2, H_3, sustained by the head at the respective points of connection F_1, F_2, F_3. When steady flow has become established, if the water in P_1 has fallen to the level H_1, then the distance $L_1 H_1$ represents the total loss of head sustained in delivery of the discharge to the point F_1. The water in P_2 will stand at a lower level H_2, the difference in level between H_1 and H_2 representing the loss of head sustained in delivering the discharge from F_1 to F_2, and the difference in level between H_2 and H_3 will similarly represent the loss of head between the points F_2 and F_3.

A line drawn through the points H_1, H_2, H_3 is called the hydraulic gradient, and it will be a straight line if the main pipe is uniform in size and roughness of surface, for the losses of head due to friction in the different sections will be directly in proportion to the respective lengths of the sections, measuring along the axis of the main pipe, quite regardless of whether it is horizontal, inclined or composed of easy bends.

The losses of head from H_1 to H_3 will be due solely to friction of the main pipe from F_1 to F_3, but the total drop of the head in P_1 from L_1 to H_1 will include, in addition to the loss from pipe friction from A to F_1, the loss of head necessary for creating the velocity of flow together with whatever loss of head which may be necessary for overcoming resistances at the very entrance. Another vertical pipe P connected in the main pipe near the reservoir (i.e., at 2½ to 3 diameters of the main) will show that a portion h of the total head is employed in this manner, and, as previously observed, the loss due to the entry head may be as much as one-third of h unless a bell-shaped aperture is employed, by means of which the head necessary for entrance may be reduced to zero.

Throttling the discharge end B has the same effect as though the discharge took place against a counterhead G, as illustrated in Fig. 7. Then the head J becomes the total effective head as in Fig. 3. The head required for entrance and velocity becomes less, because with the reduced head J less head is left for velocity and the hydraulic gradient is raised to the line $C\,D$; in fact, all conditions are the same as they would be in Fig. 5 if the total head H were reduced to the hight J in Fig. 6.

General Formulas

In discharging water from a reservoir through a long pipe, the total head is utilized, as indicated in Figs. 6 and 7, for three distinct purposes, viz.:

(a) Loss of head necessary for entrance,
(b) Head necessary for creating velocity of flow, and
(c) "Loss of head due to friction" of the pipe line.

Carefully conducted tests and experiments on long and short pipe lines under varying conditions appear to justify the following hypotheses: The loss of head due to friction

1. Is proportional to the length of the pipe,
2. Increases with the roughness of the interior surface,
3. Decreases with increase of diameter of pipe,
4. Increases nearly as the square of the velocity of flow, and
5. Loss of head is independent of pressure of the flowing water.

FIG. 5. NATURE OF PIPE-LINE RESISTANCE TO FLOW

A general form of expression for loss of head is

$$h = f \times \frac{l}{d} \times \frac{v^2}{2g},$$

in which

h = Loss of head due to friction,
f = Multiplier obtained by experiment,
l = Length of pipe in feet,
d = Diameter of pipe in feet.

v = Mean velocity of flow in feet per second,

g = 32.2, the acceleration of gravity.

Many works on hydraulics quote tables of simple coefficients for values of f when l and d or h are given, the values of f for cast-iron pipes ranging from 0.03 for small pipes and low velocities, down to 0.01 for large pipes and high velocities. A more convenient form of expression, commonly used by hydraulic engineers in making close comparisons, is the Chezy formula, which is also applicable to flow in open channels. This is

$$v = c\sqrt{r\,s},$$

in which

v = Mean velocity of water passing through the pipe,

c = Coefficient assumed as constant by some authorities and variable by many others,

r = "Hydraulic mean radius," which is the area of the cross-section of flow divided by the wet perimeter of the section, and

s = Slope $= \frac{h}{l}$.

Applied to pipes flowing full, the Chezy formula becomes

$$v = c\sqrt{\frac{d}{4} \times \frac{h}{l}}.$$

In this form of expression the multiplier c is a whole number, which for new cast-iron pipes and ordinary velocities, varies from 110 for the smaller sizes to 150 for the larger sizes. The coefficients f and c in these formulas are variable for variation of any conditions, and it is therefore difficult to construct a general formula for obtaining the loss in head which will be precisely applicable in all cases. Experiments on the flow of water in pipes which were conducted by Henry Darcy, in 1856, while director of public water supply of the city of Paris, are undoubtedly the most elaborate investigations of the kind ever executed, and are generally considered to be the highest authority. Several critics, who have made minute analyses of results reported by him, have discovered some discrepancies in observations and clerical errors of computation. However, for all practical purposes, these may be neglected.

For a general formula, applicable to all ordinary velocities and a reasonable period of service, Darcy proposed a value for f in the formula first mentioned, which reduced to English measures makes

$$f = 0.0199 - \frac{0.00167}{d},$$

in which the fractional factor varies only with the diameter. With this value for f substituted in the general theoretical formula, Darcy's general formula for the loss of head in pipes becomes

$$h = 0.0199 - \frac{0.00167}{d} \times \frac{l}{d} \times \frac{v^2}{2g}.$$

This form of expression is admitted unwieldly for everyday use, but it possesses the peculiar merit of coming as close to the truth as required for all practical purposes. Upon comparison with results obtained in a large number of carefully conducted experiments made on pipe lines in service, Darcy's formula will be found close to truth. These remarks are intended to apply to pipe lines of both wrought and cast-iron pipe, and as far as shown by published tests, they may be taken to apply with equal force to the flow in riveted iron pipe.

For a given size of pipe line and average period of service, the variation of the formula from truth will be found vastly less than the differences in actual capacities of commercial sizes next larger or smaller than the given size, and the formula will be found to cover all reasonable expectations. No formula can be devised which will provide against inordinate amount of corrosion and fouling of pipe lines unless it is a very extravagant one for use in average cases, so that whenever the stated capacity for a pipe line is imperative, the formula should be used with the same prudence in allowances for margin of safety as for other engineering works where results are mandatory. But for determining the size of iron pipe lines for average good results, engineers may safely adopt Darcy's general formula as it is, both for what it is worth and because the results are as good as can be expected of any formula, and therefore "good enough for anybody."

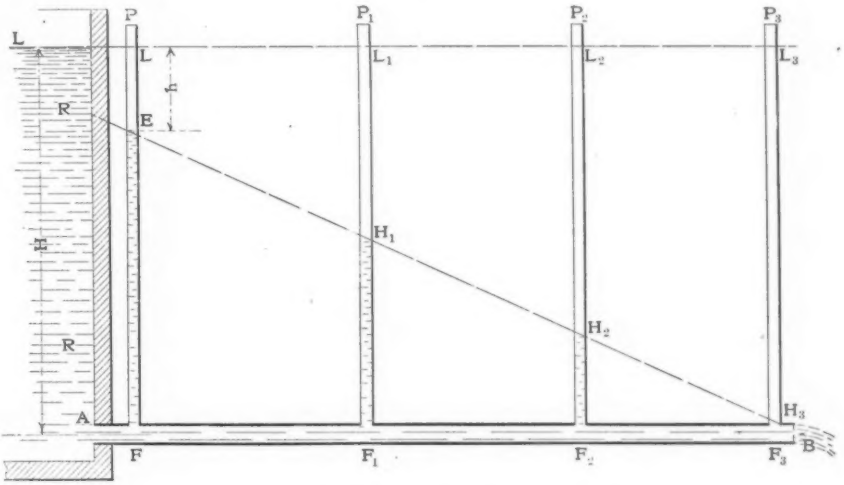


FIG. 6. ILLUSTRATING LOSS OF HEAD DUE TO FRICTION

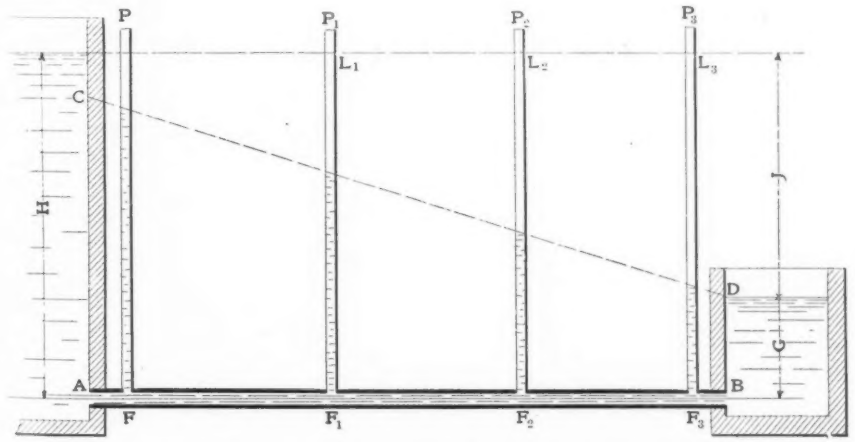


FIG. 7. DISCHARGING AGAINST COUNTERHEAD RAISES HYDRAULIC GRADIENT

Graphical Comparison of Pipe Capacities

In using formulas for determining the commercial size of pipe required for a given service, the factors of the different formulas are so combined that calculations will usually have to be made upon several assumed sizes before a satisfactory size of pipe can be selected. To save time and annoyance in making such extensive calculations, and to present a graphical comparison of capacities of different sizes of pipe, the charts, Plates I, II, III and IV, have been especially

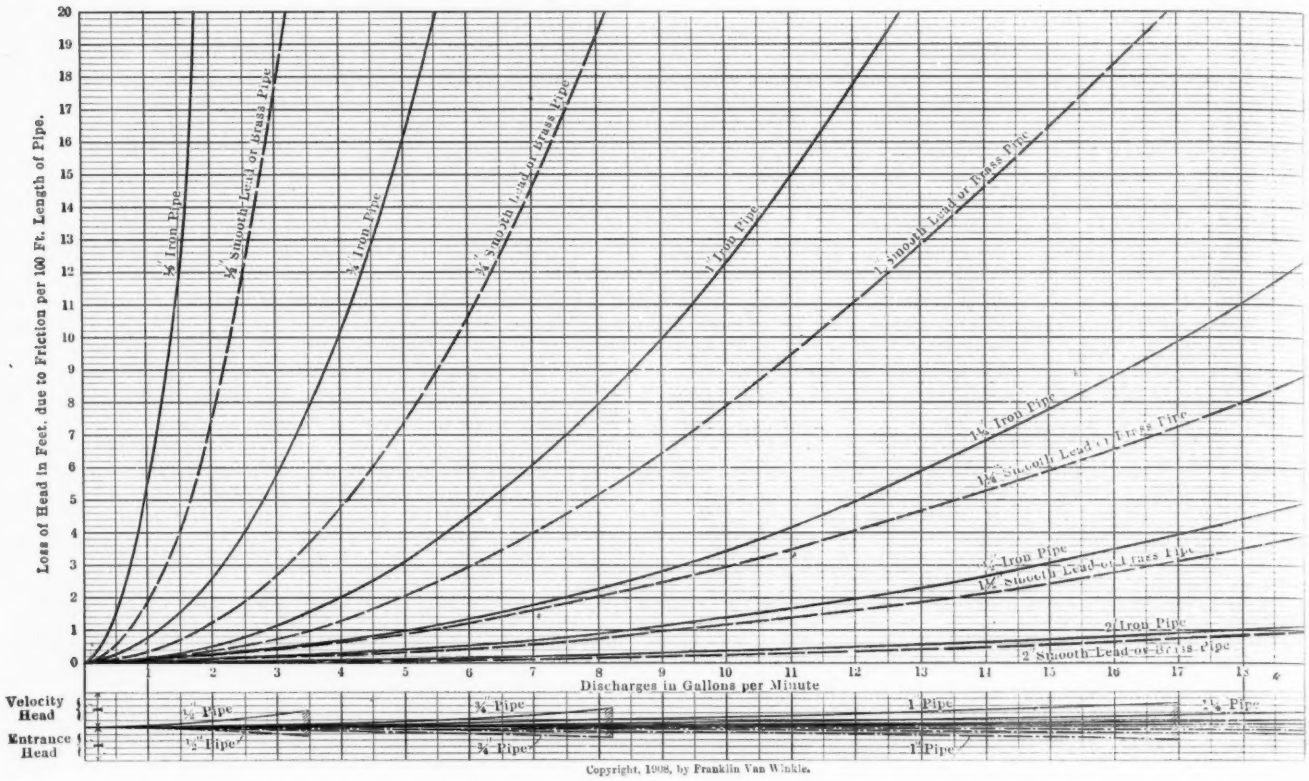

Loss of Head in Feet, due to Friction per 100 Ft. Length of Pipe.
½" Iron Pipe
½" Smooth Lead or Brass Pipe
¾" Iron Pipe
¾" Smooth Lead or Brass Pipe
1" Iron Pipe
1" Smooth Lead or Brass Pipe
1¼" Iron Pipe
1¼" Smooth Lead or Brass Pipe
1½" Iron Pipe
1½" Smooth Lead or Brass Pipe
2" Iron Pipe
2" Smooth Lead or Brass Pipe
Discharges in Gallons per Minute
Velocity Head
Entrance Head
½" Pipe
¾" Pipe
1" Pipe
1¼" Pipe
Copyright, 1908, by Franklin Van Winkle.

PLATE I. SMALL WATER-PIPE LINES

platted from Darcy's formulas to accompany this article.

The charts give loss of head in feet per 100 or per 1000 feet length of pipe for various rates of flow, in all cases reduced to gallons per minute, and cover the principal commercial sizes of pipe from ½ to 60 inches diameter, including iron pipes and the ordinary sizes of smooth-lead service pipe, the latter being platted from Darcy's formula for smooth pipes. The diagrams may be taken to represent values which are close to the average of results attained in iron-pipe lines which are in use, and should, there-

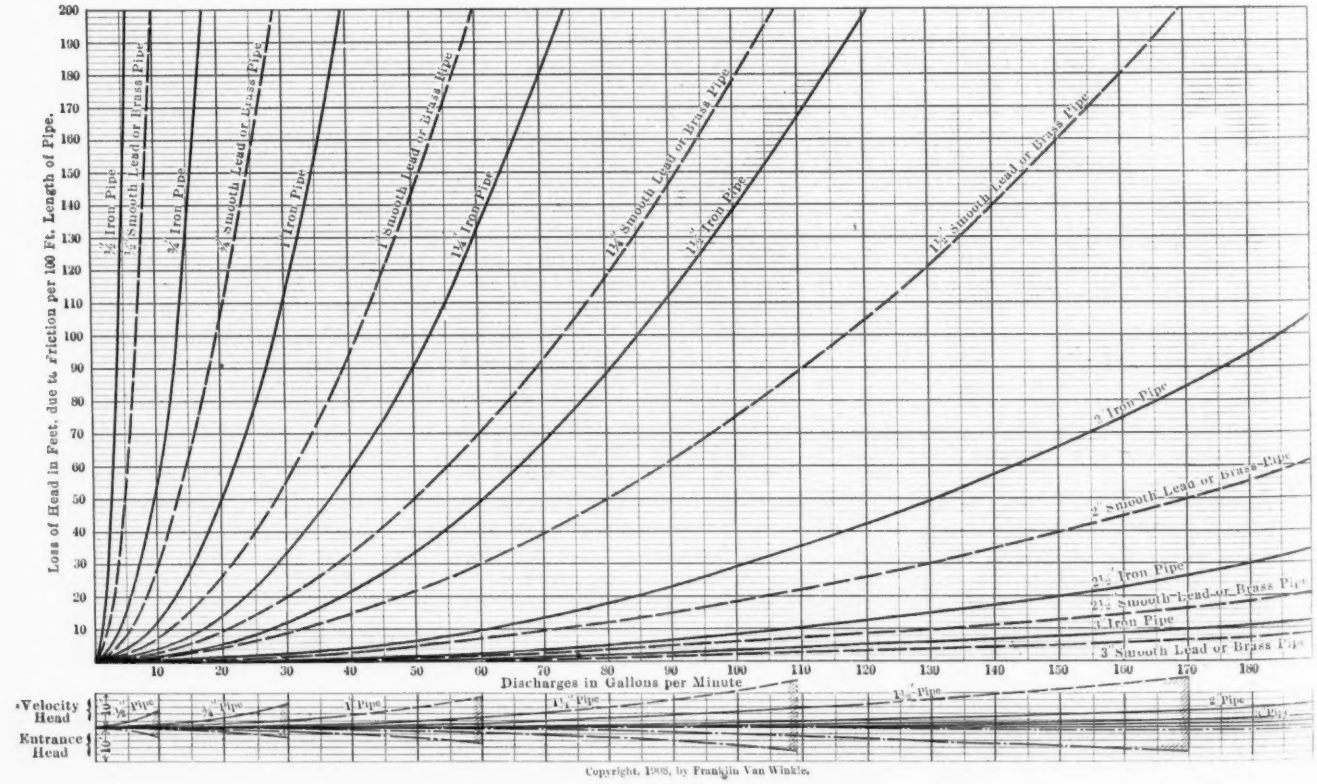

Loss of Head in Feet, due to Friction per 100 Ft. Length of Pipe.
½" Iron Pipe
½" Smooth Lead or Brass Pipe
¾" Iron Pipe
¾" Smooth Lead or Brass Pipe
1" Iron Pipe
1" Smooth Lead or Brass Pipe
1¼" Iron Pipe
1¼" Smooth Lead or Brass Pipe
1½" Iron Pipe
1½" Smooth Lead or Brass Pipe
2" Iron Pipe
2" Smooth Lead or Brass Pipe
2½" Iron Pipe
2½" Smooth Lead or Brass Pipe
3" Iron Pipe
3" Smooth Lead or Brass Pipe
Discharges in Gallons per Minute
Velocity Head
Entrance Head
½" Pipe
¾" Pipe
1" Pipe
1¼" Pipe
1½" Pipe
2" Pipe
Copyright, 1908, by Franklin Van Winkle.

PLATE II. SIZE OF FEED PIPE FOR BOILERS

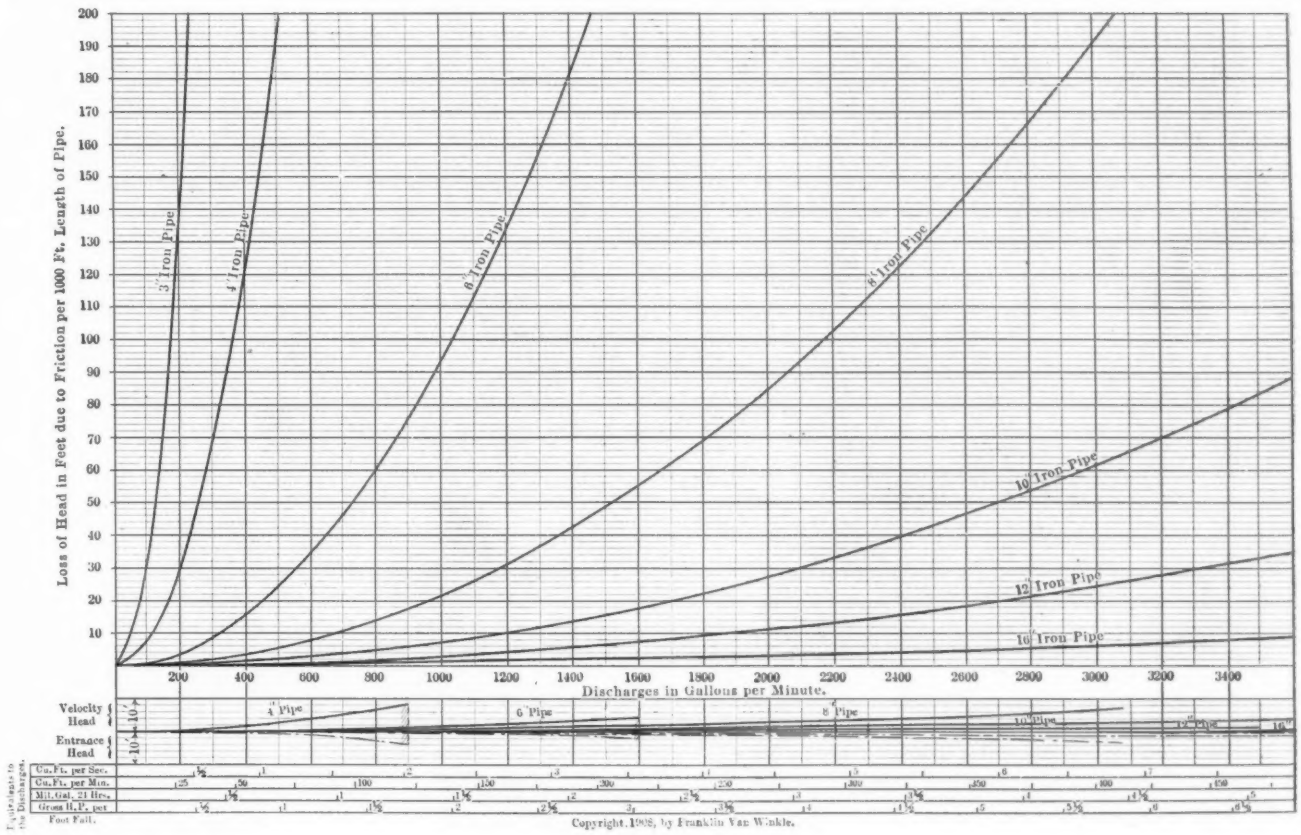

Loss of Head in Feet due to Friction per 1000 Ft. Length of Pipe.
3" Iron Pipe
4" Iron Pipe
6" Iron Pipe
8" Iron Pipe
10" Iron Pipe
12" Iron Pipe
16" Iron Pipe
Discharges in Gallons per Minute.
Velocity Head
Entrance Head
Cu. Ft. per Sec.
Cu. Ft. per Min.
Mil. Gal. 24 Hrs.
Gross H.P. per Foot Fall.
Equivalents to the Discharges.
Copyright, 1908, by Franklin Van Winkle.

PLATE III. LARGE PIPE FOR WATER SUPPLY

fore, be regarded as reasonably suitable for practical selection of the size of pipe for average conditions and average period of usefulness.

When the water is of such character that the rates of corrosion and incrustation of pipe surfaces are extraordinary, these resistances can only be allowed for by fixing upon as large initial capacity for the pipe line as may seem warrantable, considering both investment and probable rate of deterioration. In any case, where the requirements are imperative beyond ordinary commercial requirements of certainty, then an initial capacity should be selected which will embrace a factor of safety that will be appropriate to the occasion.

The known differences are so small between the flow in pipes of the same sizes, whether made of cast iron, wrought iron or steel, and also in riveted pipe of the larger sizes where comparatively low velocities are employed, that for all practical purposes for which they are recommended, the accompanying diagrams are intended to apply to all kinds of iron and steel pipe of average construction and workmanship. The range of the diagrams will be found to cover most of the conditions of head and rates of flow liable to be required in practice. In using the charts for selection of a size of pipe, it should be borne in mind that the diagrams are based on service which is attained in average pipe lines, constructed

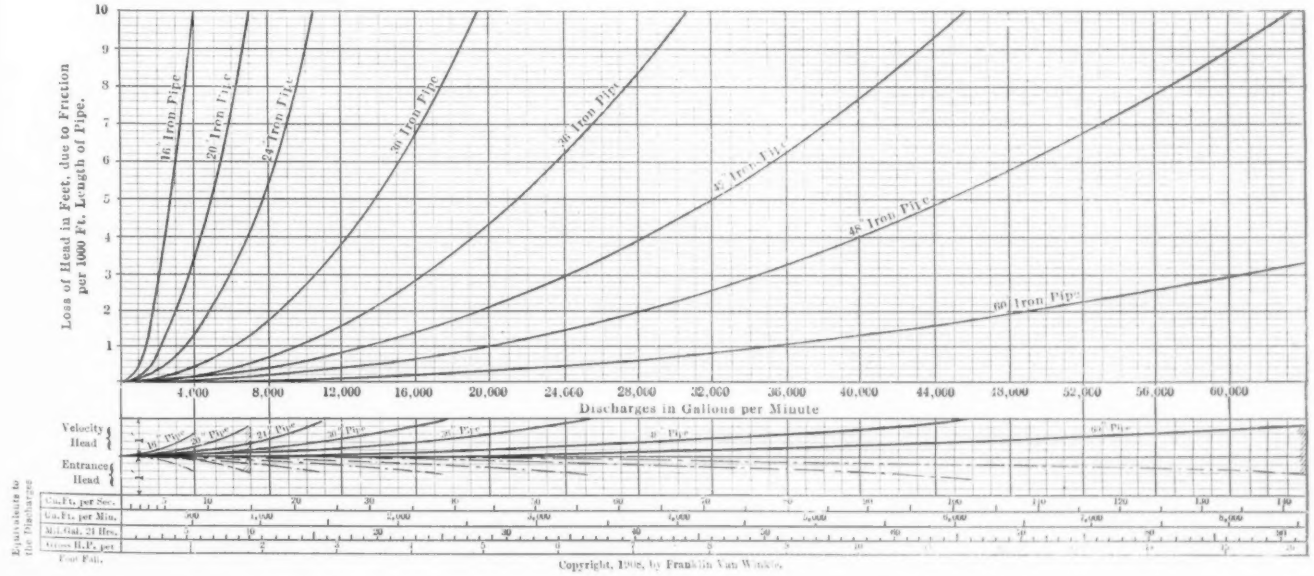

Loss of Head in Feet, due to Friction per 1000 Ft. Length of Pipe.
16" Iron Pipe
20" Iron Pipe
24" Iron Pipe
30" Iron Pipe
36" Iron Pipe
42" Iron Pipe
48" Iron Pipe
60" Iron Pipe
Discharges in Gallons per Minute
Velocity Head
Entrance Head
Cu. Ft. per Sec.
Cu. Ft. per Min.
Mil. Gal. 24 Hrs.
Gross H.P. per Foot Fall.
Equivalents to the Discharges.
Copyright, 1908, by Franklin Van Winkle.

PLATE IV. PIPE CAPACITY FOR WATER-WHEEL FLUMES

with ordinary good workmanship and materials. When the initial rate of flow has been decided upon with due regard to the kind of workmanship and any extraordinary conditions tending to corrode the pipe line or otherwise impair its carrying capacity, it will be practicable to make selection of size for pipe which may be shown by the diagrams to come within 5 per cent. of the stipulated capacity.

To render the charts more serviceable for general use, they have been constructed so as to give separately for each size of pipe the head required for velocity and the ordinary loss of entrance head for the different rates of flow, which will have to be additional to the loss of head due to friction, thus enabling the user to make a selection of the size which will utilize the total available head to the best advantage. Another feature of the charts, which should be of especial value to those interested in water supplies and water powers, is the facility afforded by the parallel scales at the foot of Plates III and IV for conversion of gallons discharged per minute into equivalents of cubic feet per second, cubic feet per minute, millions of gallons per 24 hours, and gross horsepower per foot of fall. The following examples will best serve to illustrate the practical value and method of using the charts:

Water-pipe Line for a Dwelling House

Example 1—What size of pipe should be used for a pipe line 600 feet long, in order to convey 10 gallons per minute from a spring or reservoir which has a surface elevation of 75 feet above the point where the water is to be used?

In this case we will have, per hundred feet of pipe line, a head of one-sixth of 75 feet, or 12.5 feet per hundred feet of pipe. Turning to Plate I, on the left side of the diagram find the horizontal line or space which is opposite to 12.5 feet, laid off on the vertical scale. Follow along the line or space horizontally to its intersection with the vertical line which passes through discharge of 10 gallons per minute. Then follow the 10-gallon line downward to the first pipe curve. In this case the curve for 1-inch iron pipe is first met with, intersecting the 10-gallon line at a hight which indicates a loss of head due to friction of about 11.5 feet per hundred feet of pipe. The total loss of head due to friction for 600 feet of pipe when discharging 10 gallons of water per minute would therefore be $6 \times 11.5 = 69$ feet. This would leave $75 - 69 = 6$ feet head available for the head required for velocity and entrance. Referring to the foot of the chart directly under a discharge of 10 gallons per minute, it will be found that a 1-inch pipe for that rate of flow requires a velocity head of about 0.26 foot, reading from the center line up, and an entrance head of about 0.18, reading from the center line down, making 0.44 foot total head required for entrance and velocity. A 1-inch pipe line would therefore be suitable, and there would be a surplus head of $6 - 0.44 = 5.56$ feet.

From Plate I it may be observed that a 1-inch smooth lead pipe will deliver the same 10 gallons per minute with a loss of head due to friction of 8 feet per 100 feet of pipe. Using smooth lead pipe would therefore entail a total loss of head in the 600 feet of pipe line of $6 \times 8 = 48$ feet. The head required for velocity and entrance would be the same as for 1-inch iron pipe, viz., 0.44 foot, and the total head lost in pipe-line resistances would therefore amount to 48.44 feet, thus leaving 26.56 feet of the total 75-foot head available for raising the water to a tank or to the service of fixtures at that higher elevation without diminution of the rate of flow.

In the same manner it may be seen that by employing a 1¼-inch iron pipe, 10 gallons per minute will be delivered with a loss of head of only 3½ feet per 100 feet of pipe for overcoming friction, the friction loss for 600 feet of pipe amounting to $6 \times 3\frac{1}{2} = 21$ feet, and that the loss due to velocity and entrance, when delivering at that rate of flow, amounts to only about 0.3 foot. It would therefore seem preferable in this case to employ 1¼-inch pipe, because the total pipe-line resistances, including entrance and velocity heads, would amount to only 21.3 feet, thus leaving $75 - 21.3 = 53.7$ feet head available for other purposes.

Size of Water-feed Main for a Battery of Boilers

Example 2—Neglecting any losses due to ells, what size of pipe should be used for a boiler feed-pipe line 150 feet long, not to entail a loss of over 20 pounds per square inch due to friction, when delivering at the rate of 60 gallons of water per minute?

In this case the allowable loss of 20 pounds pressure per square inch would be equivalent to a loss of head of $20 \div 0.434 = 46$ feet, and the allowable loss of head per 100 feet of pipe would be

$$46 \times \frac{100}{150} = 30.66$$

feet per 100 feet. Turning to Plate II we find the horizontal line which represents 30 feet loss of head per 100 feet, intersects the vertical line which represents 60 gallons discharge per minute on the curve for 1½-inch smooth lead pipe. Lead pipe would generally be unsuitable for a boiler feed-pipe line, although 1½-inch smooth drawn-brass pipe might be employed. Following the 60-gallon line upward to its intersection with the curve for 1½-inch iron pipe, it may be noted that the latter would entail a loss of head of nearly 50 feet, or 21.7 pounds per square inch per 100 feet of pipe, so that a larger pipe must be used if the feed pipe is to be an iron pipe. Following downward along the 60-gallon line to its point of intersection with the curve for 2-inch iron pipe, it will be seen that the diagram indicates a loss of head of 10 feet per 100 feet of feed pipe. This for the 150 feet of feed-pipe line would create 15 feet loss of head, equal to 6.51 pounds pressure per square inch. It would therefore be advisable to use 2-inch iron pipe.

Size of Water-supply Pipe for a Condensing Plant or Small Municipal Plant

Example 3—Required, the size of iron pipe for supplying 375 cubic feet of water per minute, equal to about 4 millions of gallons per 24 hours, the pipe line to be 10,000 feet long and the total available head 200 feet?

In this case the head per 1000 feet of pipe line would be $200 \div 10 = 20$ feet. Referring to Plate III, find 375 cubic feet discharge per minute on the horizontal scale at the foot of the chart, and vertically above, find the nearest equivalent discharge in gallons per minute, viz., 2800. Following the 2800-gallon line upward to the horizontal line which represents 20 feet loss of head per 1000 feet of pipe, we find it is very close to the point of intersection with the curve for 12-inch iron pipe, which is at about 21.2 feet loss of head. The 12-inch pipe curve crosses the 20-inch line at a point over a discharge of about 2725 gallons per minute. This being only 2½ per cent. less than the stated capacity, for most practical purposes a 12-inch pipe would answer, but if the demand for 375 cubic feet per minute is imperative, the next larger size of pipe should be employed

Size of Water-wheel Flume

Example 4—What diameter will be required for a water-wheel flume 100 feet long, which is to deliver water to turbine waterwheels for developing 320 net horsepower under 40-foot head, the turbines working with 80 per cent. efficiency; the loss of head due to delivery of water by the flume not to exceed 0.5 of a foot for 100 feet of flume?

With 80 per cent. efficiency, the gross horsepower in the water would need to be 400, and the gross horsepower per foot of fall would be $400 \div 40 = 10$. A loss of 0.5 foot head per 100-foot length of flume would be equivalent to 5 feet per 1000 feet of flume. Turning to Plate IV near the foot of the chart, on the scale of "Gross Horsepower per Foot of Fall," find 10, and nearly vertically above is the discharge of 40,000 gallons per minute. Following the 40,000-gallon line upward, we come to its intersection with the curve for 48-inch pipe with a loss of head of 3.9 feet per 1000 feet length of flume, showing that an 100-foot length of 48-inch flume would create 0.39 foot loss of head, and this size of flume should be used as the nearest commercial size fulfilling the requirements.

Some Recent Gas Engine Failures

By Howard S. Knowlton

Improvements in gas-engine design and a wider appreciation of the best methods of operation have contributed much in the past two or three years to the service reliability of this form of prime mover. Failures of internal-combustion engines in commercial operation are still frequent enough, however, to make the study of accidents profitable, particularly when representative breakdowns are selected. The writer recently received from Michael Longridge, the chief engineer of the British Engine, Boiler and Electrical Insurance Company, Ltd., his annual report for the year 1907, containing data bearing upon a number of recent gas-engine failures which are of more than local interest. Some of these representative faults are reviewed in the following paragraphs in the belief that they will be suggestive to operating engineers and power-plant administrators on both sides of the Atlantic:

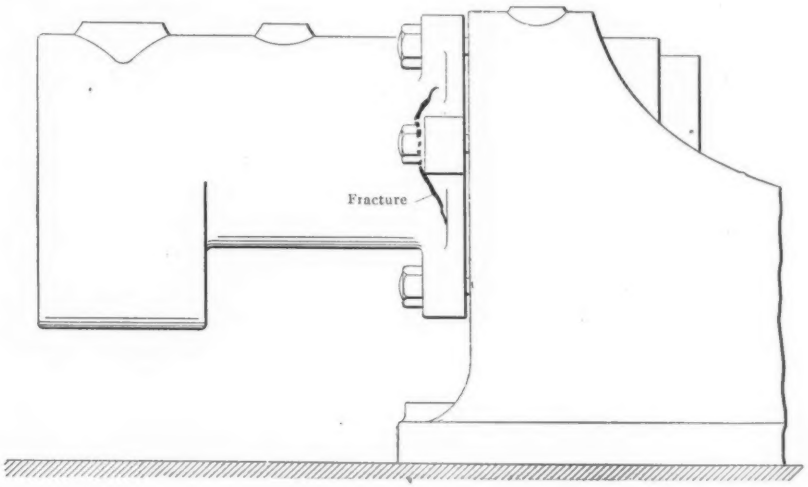


FIG. 1

Failure to drain the jackets of a gas engine in cold weather is responsible for numerous interruptions of service. In the case of five engines in one plant, running on gas from the city main, the engineer was called away one evening as he was shutting down the plant and forgot to open the jacket drains. On returning the following morning he found four of the jackets cracked from end to end and full of ice. To prevent such accidents the insurance company advised installing a stop cock on both the supply and return water pipes close to the cooling tank, and a drain cock at the lowest point of the return pipe, so that not only the jacket, but the pipes leading to and from it may be emptied. To empty the jacket only is not sufficient, for if the pipes between it and the cooling tanks be frozen the water supply will be cut off and the cylinder damaged or cracked by excessive temperature soon after it is started up again.

A breakdown occurred in the case of a horizontal gas engine with a cylinder 8x15 inches and a normal speed of 150 revolutions per minute. The fuel was lighting gas from a local main. The connecting rod was of forged steel tapering from 1⅝ to 1⅞ inches in diameter. The large end was of the marine type with two ¾-inch bolts. The eye at the small end, instead of being solid, was divided vertically, the half farthest from the crank forming a cap which was secured by two ½-inch bolts. One of the bolts broke at the bottom of the thread while the engine was running at the ordinary speed. Breakage of the other followed, and the rod, freed from the piston, broke the latter, knocked a hole through the bedplate, and was itself broken near each end. The crank-pin brasses were also damaged and the bolts at the larger end bent. The unusual incident of the breakdown was the fracture of the rod in two places. The fractures were clean without any signs of bending or stretching. The inertia stress upon the two ½-inch bolts was about 740 pounds, or about 3070 pounds per square inch of sectional area at the bottom of the threads.

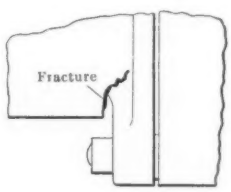


FIG. 2

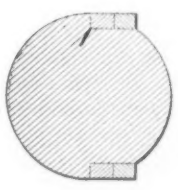


FIG. 3

FIG. 4

Piston, Cylinder and Jacket Trouble

A case of piston, cylinder and jacket trouble occurred with a 15⅞x23-inch engine having a normal speed of 184 revolutions per minute. The large end of the connecting rod was of the marine type with the bolts 9¼ inches long between the head and the screw, and 2¼ inches long in the screw. The bolts were 1¼ inches in diameter, except for a length of 1⅞ inches in the middle of the shank, where the diameter was reduced to $1\frac{5}{32}$ inches. The thread pitch was seven per inch. In operation one morning the upper of the two bolts broke through the thread next the shank, the lower bolt was stretched until its diameter was reduced 1/16 inch, and then broke at the reduced section. The piston was forced back into the clearance and cracked circumferentially half way round the groove for the ring next the head. The cylinder end, liner and jacket were all broken, and the connecting rod and valve stems bent. The stress upon the bolts due to the inertia of the moving parts was about 5030 pounds per square inch of sectional area at the bottom of the screw thread, assuming the stress to be equally distributed between the two bolts. Besides the normal stress due to inertia, the bolts had been subjected to abnormal stress soon after the engine was set at work, by the piston seizing and splitting the back end of the liner. The engine had made about 33,100,000 revolutions in service prior to the breakdown.

A failure occurred in the case of an 18x20-inch engine making 162 revolutions per minute. The small end of the connecting rod was forged with a flat palm, to which the two brasses and the cap were held by two bolts 1½ inches in diameter with six threads per inch. Shortly after starting the engine one of the bolts in the small end of the connecting rod broke through the screw thread, the outside brass and cap were torn off, the palm at the end of the rod was bent and the other bolt broken. The cylinder liner was broken, the piston cracked, and the connecting rod bent. The stress upon the bolts, due to the inertia of the piston, was about 2220 pounds per square inch of sectional area at the bottom of the threads. The stress due to the friction of the piston was unknown. The engine had made about 103,500,000 revolutions.

A horizontal gas engine seven months old, with a 20x30-inch cylinder, ran at 160 revolutions per minute on suction-producer gas. After a shutdown for the noon hour one day the engineer found that he could not start the machine, and observed water running down the ex-

haust-valve stem. He concluded that the joint between the liner and the water jacket was leaking, removed the covers to examine the compression chamber and found about a gallon of water inside, and a crack about 7 inches long in the side of the chamber near the spark plug. A new cylinder end was ordered from the maker's stock and an inspector sent to examine it before it was sent off. He found several of the ribs connecting the outer to the inner walls of the jacket cracked, although the casting had never been in use. The cracks were not long enough to render the end unserviceable, but safety required its condemnation. The cause of the first fracture was uncertain, though as the jacket was clean it was probably a stress produced by unequal expansion of different parts of the casting. The cause of the second was plainly contraction of the inner wall of the jacket after the outer wall had become set. If the core of the compression chamber had been removed and the casting cooled from the inside, the ribs would probably have remained sound.

An Unusual Accident

An unusual accident happened to a 16x23-inch gas engine running at 160 revolutions per minute. The cylinder was fastened to the end of the bed frame by six studs 1¾ inches in diameter, screwed into the frame and passing through six radial lugs cast upon the front end of the cylinder jacket at equal distances around its circumference, and by nuts on the ends of the studs. The lugs were not faced across flush with the end of the water jacket, but were set back from the faced end surface so that there was a space of ½ inch between them and the end, as indicated by Figs. 1 and 2. By tightening the bolts the lugs were submitted to a bending and a shearing stress, which in the case of one seems to have been high enough to start the crack shown. The studs were threaded with five threads per inch, so that for every inch of wrench length used for tightening the nut the load on the bolt was thirty-one times the pull upon the end of the wrench. With a 24-inch spanner and a 100-pound pull 4 inches from the end of the spanner, the load upon the bolt would be 62,000 pounds. If the leverage were increased on the spanner the load on the bolts and the strain on the casting could easily be increased beyond the resistance of the cast iron. As the nuts had been tightened since erection on account of the cylinder springing, it is probable that this was the cause of the crack.

A horizontal gas engine six years old, with cylinder 4½x7½ inches, and a normal speed of 250 revolutions per minute, operating on illuminating gas, had a large-end connecting rod of the marine type, with two bolts ½ inch in diameter reduced to 7/16 inch in the middle of the shank. The crank pin began to knock, and the brasses were taken off and stripped. After these were returned, the knocking continued, requiring the stopping of the engine. The upper of the two large-end bolts was broken through the bottom of the thread next the shank, and the other one bent. It was found that the screw thread had not been continued far enough down the shank to allow the brasses to be tightened after and perhaps before they had been stripped. The long-

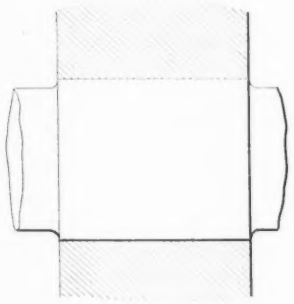


FIG. 5

continued succession of blows upon the bolts while the engine was running with slack brasses, culminating in still heavier blows after the brasses had been stripped, had probably started and completed the fracture. The stress on the bolts due to the inertia of the moving parts was about 2050 pounds per square inch of sectional area.

A Flywheel Breakdown

A flywheel-breakdown occurred in the case of a 10x18-inch engine thirteen months old, driving a machine-tool equipment with gas from the city main. The

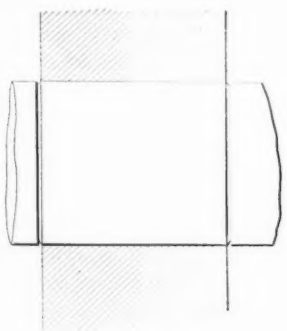


FIG. 6

speed was 170 revolutions per minute. The engine had two flywheels, each 5 feet 3 inches in diameter, cast solid with six curved arms and a boss 9 inches in diameter. The center of one wheel was 17½ inches from the right-hand end of the shaft, and the center of the other 35½ inches from the left-hand end, which also carried the driving pulley. The shaft was 4½ inches in diameter, and each wheel was secured by a single sunk key. The flywheel on the left-hand end collapsed suddenly when the engine was carrying normal load. The boss was split through the keyway, and all the arms were broken. The cause of the breakdown was a poorly-fitting key. An examination of the parts after the breakdown showed the upper surface of the key was polished by being rubbed, and the edges were bruised, while the lower surface had only been in contact with the shaft at the edges. The sides of the key were also rubbed and slightly indented by the edges of the keyway in the shaft. The internal surface of the boss of the wheel, including the keyway, was battered and polished by rubbing, as was also the surface of the shaft which had been in contact with it. It appeared that originally the key had fitted hard against the sides of the keyway in the shaft, and wore lightly against the bed of the keyway in the boss. The boss had not fitted the shaft, and the surfaces of the shaft bearing against the sides of the key had been too small to stand the pressure without deformation and wear. The key thus loosened allowed the wheel to rock and split the boss from one corner of the keyway. This is a typical case, and it suggests that the method of casting flywheels of gas engines with solid bosses, and securing them with one or two sunk keys, might be changed to advantage. The first objection is that if the shaft ends are made without taper and long enough to carry a driving pulley outside the flywheel, it is difficult to force the tightly-fitting wheel home. The other disadvantages are in sinking the keyway deep enough without unduly weakening the shaft, and in fitting the key accurately. A sunk key of the usual dimensions would be effective only by fitting on all sides, which is practically impossible. The fitter must choose between the top and bottom surfaces of the key on the one hand and the sides of the key on the other. In the first case the key is too narrow, and in the second the bearing surface is too small, particularly upon the shaft.

It would seem to be better to use broad keys fitted upon flats upon the shaft if the wheel is to be held by radial pressure, but if tangential pressure is to be relied upon, to secure it by keys fitted as indicated in Figs. 3 and 4. The objection to such keys is that the keyways weaken the shaft, and the pressure of the key upon the edge of a keyway in a steel shaft tends to start a crack, as indicated in Fig. 3. A better plan seems to be to split the boss of the wheel, bore it slightly smaller than the diameter of the shaft, wedge the two halves apart, slip the wheel upon the shaft, withdraw the wedge and secure by two or four bolts, dispensing with keys altogether. If this method be adopted, the part of the shaft gripped by the boss should be of slightly larger diameter than the part outside it, as indicated by Figs. 5 and 6, so that the edges of the boss may not indent the skin of the shaft and start a crack.

Methods of Guarding Against Lightning

The Problem of Choosing Efficient Lightning Protectors; Essential Features Required in Arresters; Different Types Described

BY W. T. RYAN

Lightning discharges occurring in the neighborhood of transmission lines affect the line in one of two ways. First, by the direct "stroke," when the line and possibly some of the apparatus connected to it become part of the path over which the terrific discharge from clouds to earth takes place. Against this form of lightning there is no protection. The second way is by the occurrence of lightning discharges in the neighborhood of the line either from cloud to cloud or from cloud to earth, but not directly to the line. It has two effects on the line; one is a magnetic effect, which induces a sudden rush of current in the line. If this rush of current encounters a portion of the circuit, such as the windings of a transformer, in which there is considerable inductance, a very great difference of potential will be created between the terminals of that portion of the circuit, which is almost sure to break down the insulation at the entrance to the winding. The second effect is the sudden release of any electrostatic charge which might have accumulated on the line; when this occurs the static discharge tends toward the earth. If this tendency or pressure is great enough, the insulation of the system will give way at its weakest point, which is usually over the surfaces of an insulator and pole out on the line or through the insulation of some of the machinery connected to the line. A lightning arrester is a device for shielding electrical apparatus from the abnormal strains due to these electromagnetic and electrostatic effects.

It is not generally appreciated that a very great deal of scientific research has been done by electrical engineers in their attempts to solve the problem of lightning protectors. Continuity of service is of prime importance in every transmission system. Without proper protective apparatus, carefully inspected and cared for, a great many systems would be subject to frequent shutdowns and serious damage to the station apparatus.

Protective Devices

There is a vast difference of opinion among engineers as to the value of the various protective devices. The ideal protector should prevent any rise of voltage dangerous to insulation, should perform its functions without disturbing the operation of the system, and should successfully rupture the arc and discharge at a certain voltage for any frequency.

The fact that in practically all lightning arresters the discharging e.m.f. depends on the frequency accounts more than anything else for the very great variation in the effectiveness of the protection afforded.

The essential features of a lightning arrester are a spark gap between the line and the ground and an inductive or choke coil between the spark gap and the ap-

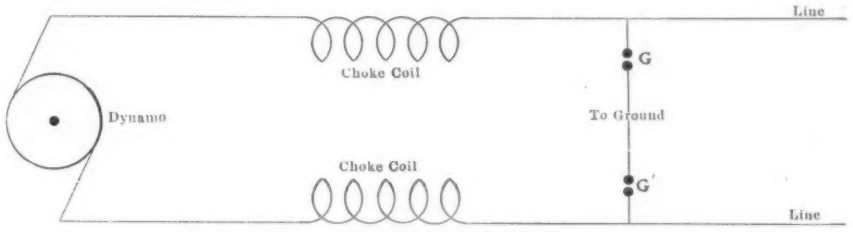


FIG. 1. CHOKE COILS

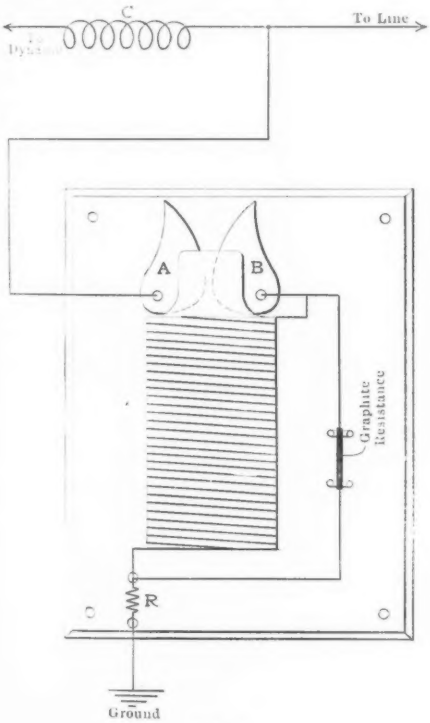


FIG. 2

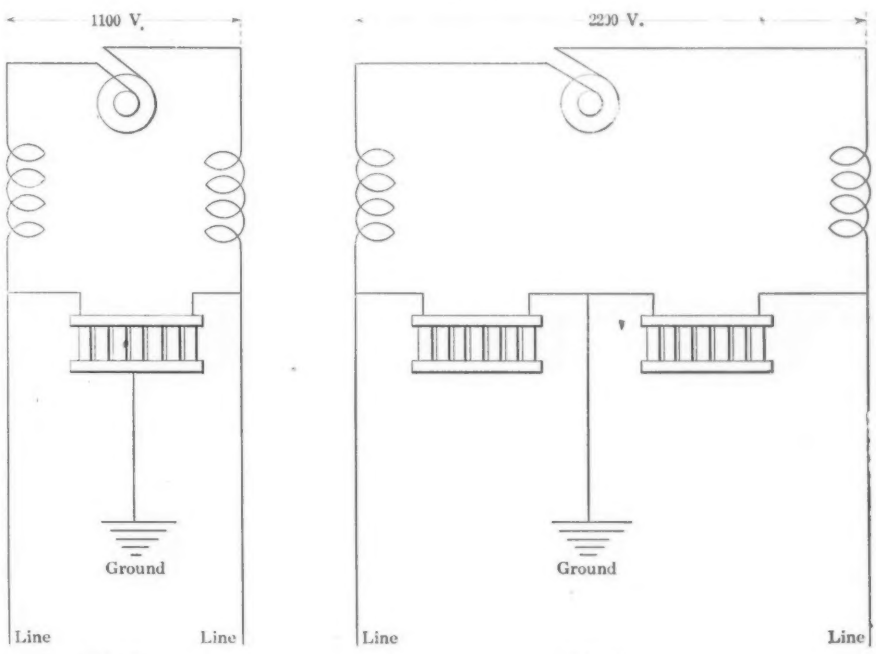


FIG. 3 FIG. 4

CONNECTIONS OF NON-ARCING LIGHTNING ARRESTER FOR SYSTEMS OF FROM 500 TO 2500 VOLTS

paratus to be protected. Fig. 1 illustrates this principle diagrammatically. Each of the line wires upon entering the station is connected to a choke coil, and immediately in front of the choke coils of each line wire there are ground connections interrupted by spark gaps, as at G and G'. A rush of current entering the station over the line wires will be dammed up, so to speak, by the choke coil until the differ-

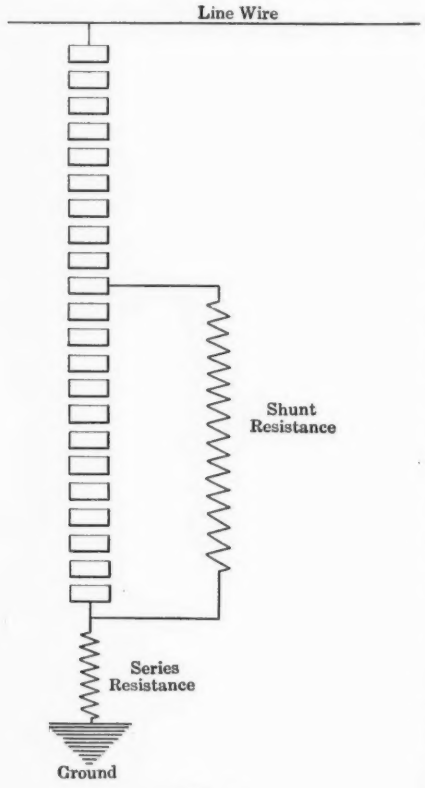


FIG. 5

ence of potential increases sufficiently to break across the gaps G and G' and establish a conducting path to earth.

When arcs are started across the spark gaps G and G, they constitute for the instant a low-resistance path between the terminals of the dynamo, virtually short-circuiting it. Therefore, some means must be provided for extinguishing the arc immediately after the discharge has taken place. It is in this provision that most of the types of lightning arrester in use differ. The principal methods of extinguishing the arc are by (a) blowing it out magnetically, (b) using a non-arcing metal at the gaps, (c) smothering the arc in a tight chamber, and (d) inserting a resistance in series with the ground connection. The various types of lightning arrester in use at the present time might be classified as follows: Magnetic blowout; non-arcing, multiple-gap; moving electrode, loose coherer; fixed coherer; diverging air-gap, or "horn" type, and adjacent ground wires.

One of the first effective lightning arresters to be put into actual use was the magnetic blowout type invented by Prof. Elihu Thomson. A conductor carrying a current across a magnetic field tends to be moved or deflected by the magnetic field, and this is true whether the conductor be a wire or a conducting gas or vapor. Hence if a lightning arrester is provided with a magnet, placed so that the arc is formed in the field of the magnet, the arc will be repelled or "blown out," provided the direction of the magnetic flux and that of the current are properly arranged. Fig. 2 shows a very common type of a single-pole magnetic-blowout arrester for direct-current circuits. The spark gap is between the two wing-shaped pieces of brass A and B, which are set between the poles of an electromagnet; the pole in front of the wings is shown in the figure. The winding of the electromagnet forms a shunt around a graphite resistance and part of the current which continues to flow across the gap after the lightning discharge has passed, quickly excites the magnet and blows out the arc in the spark gap between the two wing-shaped pieces of brass. The choke coil C between the spark gap and the apparatus to be protected must be extremely well insulated. It usually consists of an insulated copper ribbon wound like a roll of tape. A resistance R is sometimes inserted in the ground connection to limit the current which can flow after a discharge has occurred.

The Wurtz non-arcing lightning arrester is perhaps the simplest of its type. It also belongs in the class of multigap arresters. Figs. 3 and 4 illustrate the connections of this arrester as made for circuits of from 500 to 2500 volts. It consists of seven cylinders, each 1 inch in diameter and 3 inches long, placed side by side with air gaps of 1/64 inch between them. The cylinders are held in place by strips of marble and the cylinders are nurled or checkered, to present hundreds of confronting points for facilitating the discharge. The non-arcing property of the metal in the cylinders is depended upon to rupture the arc after a discharge takes place.

On circuits of less than 1250 volts the generator terminals are connected to the end cylinders and the ground line to the center one, as in Fig. 3. This makes the device double-pole, and one arrester is therefore sufficient for both sides of the line. When the potential is greater than 1250 and less than 2500, an entire seven-cylinder unit is connected between each line wire and the ground, as in Fig. 4. There are certain metals, the principal of which are zinc, cadmium, mercury, antimony and bismuth, which pass the non-arcing property due to their high volatility. The sudden evolution of considerable metallic vapor between the cylinders tends to blow out the arcs as well as to dissipate the heat. The material actually used in the arrester is an alloy of zinc with just sufficient copper to enable it to be easily cast and worked.

High-potential Arresters

For very high potentials the type of arrester most widely used consists of a large number of small air gaps in series between metal cylinders composed of these non-arcing materials. A resistance is connected in series with the gaps and part of them are shunted by another resistance. The principle upon which the action of this arrester is based is shown by Fig. 5.

To cause a discharge the potential at the line must rise until it is sufficient to jump across the gaps. The arc which tends to follow the discharge is then withdrawn from the shunted gaps by the shunted resistance which has been thrown in multiple with them. The arc is then suppressed in the remaining gaps by both of the resistances in series.

For line potentials of 25,000 volts or

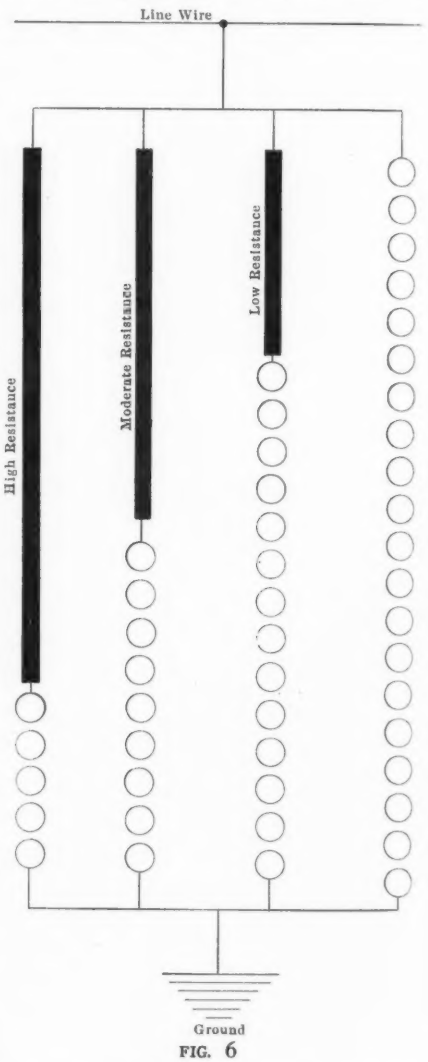


FIG. 6

over the choke coils are usually replaced by static interrupters. A static interrupter consists of a choke coil in series with the line and a condenser, one terminal of which is connected between the choke coil and the apparatus to be protected and the other to such parts as have electrostatic capacity with the high-tension winding. In a transformer this connection is usually made to the neutral

point of the low-tension winding, the care and the ground. By combining a condenser with a choke coil in this manner a small coil can be made to afford the same protection as a coil alone of much larger dimensions. The condenser permits the passage through the choke coil of some current which does not flow onto and through the apparatus, but merely charges the condenser. On the lower-potential lines the apparatus and connecting wires usually have sufficient static capacity, making it unnecessary to use a condenser.

The graded resistance form of multi-gap non-arcing arrester, very recently put on the market, was designed to discharge with equal facility at both high and low frequencies, removing to a certain extent the usual drawback due to variations in frequency. The arrangement of gaps and resistances as shown in Fig. 6 is used. Low frequency discharges are not impeded as much by resistance, but can break through only a few air gaps for the same voltage as compared with a high frequency. For a given voltage, then, the low frequency and accumulated static charge will break through the path with the highest resistance; frequencies somewhat higher will break through the path with moderate resistance and the still higher frequencies through the path with gaps only. The gaps are between cylinders made of non-arcing metal and the arrester is so designed that should the arc pass across all the gaps following a discharge the number of gaps is sufficient to extinguish the arc, and this holds with each resistance and the gaps connected to it. This combined with the shunting effect of the resistances makes sure the extinguishing of the arc.

Filtering Oil for Repeated Use

By John M. Howland

For the purpose of collecting and purifying oil after its use in power plants to lubricate the moving parts of machinery, so that it may be utilized over and over again, filters of various types and operating on different principles have been placed on the market in considerable number. Among the filtering materials used are wicking, cotton waste, canton flannel, toweling, felt, sponges, sawdust, charcoal and sand, the fibrous matter being contained in perforated receptacles and the granular substances in screened-off layers. The principles of operation include application of hydraulic pressure, centrifugal force, capillary attraction and precipitation of impurities during slow, tortuous travel of the oil. Steam coils are also largely used in heating the lubricant for a portion of its passage, so that its gravity and viscosity may be lowered, thereby enabling the impurities to be more freely precipitated. The previous description outlines in general the construction and operation of most filters, but in the power plant of the Falk company, at Milwaukee, there is employed a special method of filtering, the details of which are as follows:

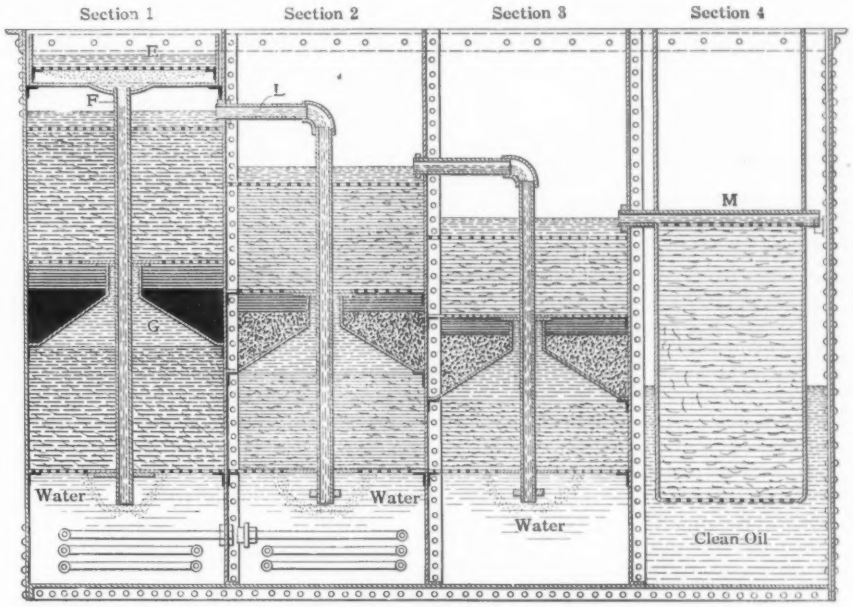


FIG. 2. SECTION THROUGH TURNER OIL FILTER

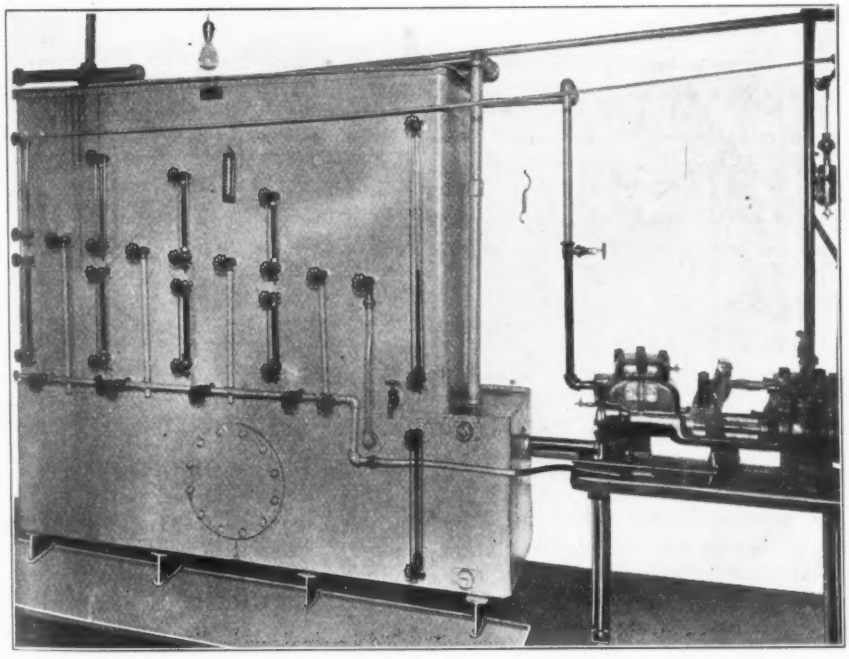


FIG. 1. FIVE-CHAMBER TURNER FILTER AND OIL PUMP

What is known as the gravity system of circulation is used for all of the four generator and air-compressor units installed at the plant. After having served its purpose the oil flows to a five-chamber Turner filter in the basement and is pumped back to a 200-gallon tank, located under the ceiling of the engine room, by means of a 4½x2¾x4-inch pump of Platt Iron Works make, which, with the filter, is shown in Fig. 1. The capacity of the system is 450 barrels daily, and the filter has a receiving tank of 175 gallons storage capacity placed beneath it.

Oil runs from the base of each engine to a filter comprising five sections, through which it passes successively, making its total travel more than 25 feet. During this period it is undergoing continuous cleansing. From the fifth section the clean oil passes through a pipe controlled by a valve directly into the receiving tank, and from there it is raised by the pump previously mentioned to an elevated tank, from which it is piped to the bearings. The advantages claimed for the combination are that it is in compact form requiring but little room for the

quantity of oil handled, that the lubricant is thoroughly cleansed and that the filter requires little attention. The operation of the filter will be apparent from Fig. 2, which is a diagram of a four-section filter.

Dirty oil, pouring into the pan *E*, passes through a fine strainer and descends through the vertical pipe *F*, discharging into water below a perforated plate near the bottom of Section 1. Thence it rises in a diffused state through the first filtering bed of fine, long excelsior. Above this it is deflected along the inclined sides of the cone *G* to the center, where it passes through small openings and strikes another horizontal perforated plate immediately above, and is again spread out over the area of the section. After passing this second perforated plate, it rises through the second filtering bed and overflows through pipe *L* into Section 2, repeating the same operation in Sections 2 and 3 as in Section 1. The oil enters Section 4 through pipe *M*, and, descending through the filtering bed, enters the clean-oil reservoir from the bottom of the cylinder.

The action of the steam coil, shown in the diagram, is to thin the oil to a consistency best suited to filtration. The water washes away the grit, causing the heavy dirt to fall to the bottom of the filter. Diffusion, by contact with the horizontal plates and passage through the beds of excelsior, separates the oil into fine particles to be more effectually washed and the dirt liberated. The heavy dirt settling in the dirt chamber can be drawn off through a valve provided for that purpose. The dirt held in suspension and not heavy enough to settle is readily taken up by the excelsior. There is a ¾-inch layer of hair felt immediately above the perforated plate in the bottom of the last filtering bed in Section 3. This, with the motion in an upward direction, is an effective strainer. The arrangement of the dirt chambers with provision for drawing off, as stated, is an advantage in practice, as it does away with the passing of oil through the impurities left by previous filtration. The downward movement in the cylindrical tank in Section 4 insures the stoppage of any floating particles which may have passed over from the last filtering bed.

The motion throughout the process of filtration is in a natural direction, the oil being in constant and steady motion for the entire period, and it will be seen that the action of gravity is assisted by the construction of the filter. The clean oil is free from water, and ample storage capacity is provided for it. The pump and gravity tank, with suitable piping, saves all handling and makes an oiling system that is complete in every detail required for continuous operation.

Setting the Valves of the Westinghouse Three Cylinder Gas Engine

By J. C. Parmely

On the Westinghouse three-cylinder vertical gas engine the exhaust-valve chamber is on the rear side of the cylinders, and the valves are operated by a cam shaft inclosed in the crank case directly below them. Another cam shaft, held in brackets above the cylinder heads and on the front side of the engine, actuates the admission valves and the igniters. The release cam shaft is driven by reduction gearing from the crank shaft and the inlet cam shaft is driven by the release cam shaft through suitable gears and a vertical shaft. The gears are numbered consecutively as they occur in the train, beginning with No. 1 on the crank shaft and ending with No. 10 on the inlet cam shaft.

There are various ways by which to determine the degrees on the flywheel of an engine. They may be measured off and marked permanently with a chisel, or a tape line may be drawn closely around the rim of the flywheel and the readings taken in inches and later changed to degrees. In either case it is necessary to suspend a plumb line in front of the flywheel, perpendicular to the center of the crank shaft, from which to take the readings. Another method is to construct a dial for this purpose, as indicated in Fig. 1. The dial is preferably made of heavy sheet iron and is attached firmly to the right end of the crank shaft by means of a clamp fastened to its back. The degrees are marked on its periphery, and the positions of the three cranks are also denoted. A string fastened at its center and held vertically by a weight serves as a zero mark from which to take the readings.

In order to set all the valves, it is necessary to set the exhaust and inlet cam shafts for one event of one cylinder, for the cams are spaced 120 degrees apart on the shafts, and the remaining operations will take care of themselves. The igniters must be set separately. First, set the release cam shaft; disengage gears 3 and 4 by means of a clamp and set for the events in the middle cylinder. Table 1 shows that the exhaust valve should close 10 degrees after the crank has passed the top center. Turn the flywheel until the crank is in this position, as indicated by the dial, and turn the cam shaft in the proper direction until the valve just seats; this condition can be determined by twisting the valve; it will be impossible to twist the stem when the valve seats. Next bring the gears into mesh again and the release cam shaft is set.

The inlet cam shaft may be set in the same manner, disengaging gears 9 and 10 and turning the crank to the position for the one event. In setting this cam shaft, if the release cam shaft has been set previously, be sure that the inlet valve starts to open 10 degrees before the crank reaches the top center on the *exhaust* stroke, not on the *compression* stroke.

The igniter cams must be set separately.

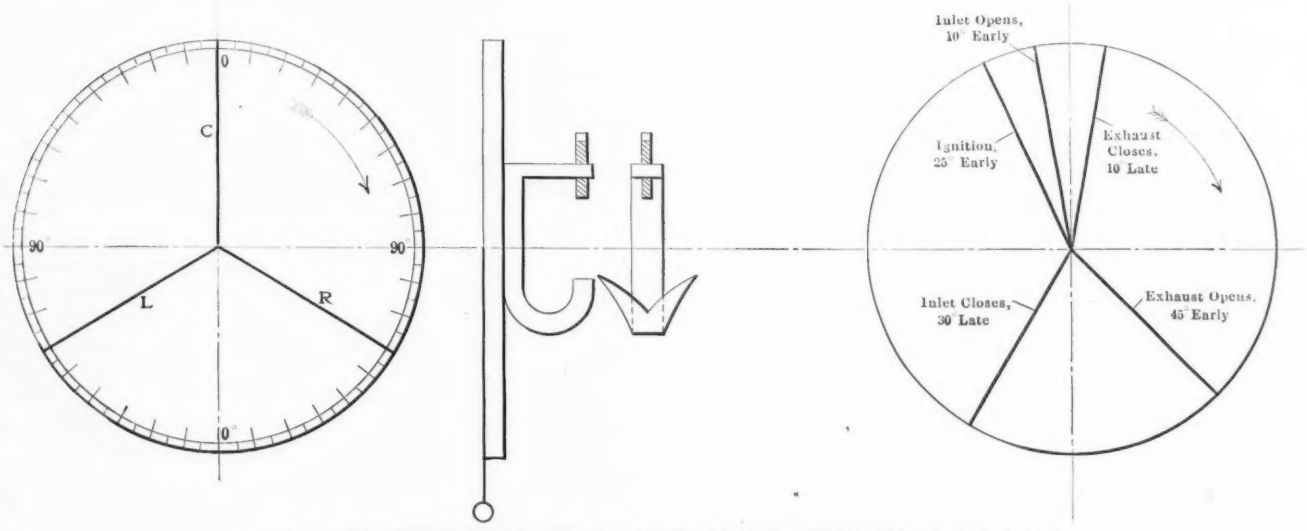


FIG. 1. FOR SETTING THE VALVES OF A WESTINGHOUSE THREE-CYLINDER GAS ENGINE

Turn the crank until it reaches the position of 25 degrees before top center on the compression stroke, and set the cam so that the igniter just trips. Of course, it may be impossible to set the valves precisely as the table indicates, on account of the meshing of the gear teeth; take the nearest meshing and bring the events as near the table as possible by adjusting the clearance at the cams. The clearance is an important factor in the valve setting and must be given careful consideration, for an allowance must be made for the expansion of the stems when they are heated, and, if clearance enough is not given, the valve may be partly opened before it should, and be held open after it should be closed.

TABLE I. (Compare with Fig. 2.)

Inlet valve opens	10 degrees before top center.
Inlet valve closes	30 degrees past bottom center.
Exhaust valve opens	45 degrees before bottom center.
Exhaust valve closes	10 degrees past top center.
Ignition	25 degrees before top center.

TABLE 2. IDEAL VALVE SETTINGS AND ORDER OF EVENTS.

Order of Events.	Cylinder.	Event.	Cam Shaft Angle.	Crank Angle.	Crank Angle.
1	Center	Exhaust closes	5 deg.	10 deg. First rev.	10 deg. late
2	Right	Inlet closes	45 deg.	90 deg.	30 deg. late
3	Left	Inlet opens	55 deg.	110 deg.	10 deg. early
4	Left	Exhaust closes	65 deg.	130 deg.	10 deg. late
5	Center	Inlet closes	105 deg.	210 deg.	30 deg. late
6	Right	Ignition	107½ deg.	215 deg.	25 deg. early
7	Left	Inlet closes	165 deg.	330 deg.	30 deg. late
8	Center	Ignition	167½ deg.	335 deg.	25 deg. early
9	Right	Exhaust opens	187½ deg.	15 deg. Second rev.	45 deg. early
10	Left	Ignition	227½ deg.	95 deg.	25 deg. early
11	Center	Exhaust opens	247½ deg.	135 deg.	45 deg. early
12	Right	Inlet opens	295 deg.	230 deg.	10 deg. early
13	Right	Exhaust closes	305 deg.	250 deg.	10 deg. late
14	Left	Exhaust opens	307½ deg.	255 deg.	45 deg. early
15	Center	Inlet opens	355 deg.	350 deg.	10 deg. early

TABLE 3. ACTUAL VALVE SETTINGS, TAKEN ON A THREE-CYLINDER 11x12 ENGINE.

Event.	Cylinder.	As Received.	As Corrected.
Exhaust opens	Right	60 deg. early	50 deg. early
	Center	60 deg. early	47 deg. early
	Left	60 deg. early	45 deg. early
Exhaust closes	Right	5 deg. early	10 deg. late
	Center	0 deg. early	15 deg. late
	Left	0 deg. early	17 deg. late
Inlet opens	Right	12 deg. early	14 deg. early
	Center	12 deg. early	15 deg. early
	Left	12 deg. early	13 deg. early
Inlet closes	Right	48 deg. late	42 deg. late
	Center	48 deg. late	43 deg. late
	Left	46 deg. late	42 deg. late
Ignition	Right	25 deg. early	
	Center	23 deg. early	
	Left	25 deg. early	

The valves should be set as nearly as possible to correspond with the accompanying tables.

In using natural gas the ignition should not be set to occur more than 26 degrees early, on account of slow speeds, but in using artificial gas the time of ignition must be changed.

The Armour Engineer is the title of a semi-annual technical publication which is to be issued by the student body of Armour Institute of Technology, Chicago, Ill. The first volume will be published during the present semester and is to contain technical articles by prominent Armour graduates, results of research in the Armour testing laboratories, papers presented to engineering societies, etc.

Possibilities of Low Pressure Turbines

As showing the possibilities of low-pressure turbines utilizing the exhaust of highly efficient reciprocating engines, Charles B. Burleigh, in a paper recently presented to the National Association of Cotton Manufacturers, quotes a report submitted by Lionel S. Marks, assistant professor of mechanical engineering at Harvard University, to the management of the Cambridge Electric Light Company. This report, somewhat abridged, is as follows:

In compliance with your request, I submit the following report on the economic possibilities of a steam turbine in the Cambridge Electric Light Station:

There are at present in the station two 500-kilowatt steam engines, one 1500-kilowatt steam engine and one 2000-kilowatt steam engines, both of the McIntosh & Seymour type. They are designed to run with a possible overload of 50 per cent. for a short time. There is, therefore, a possible normal output of 4500 kilowatts, or, for a short time, of 6750 kilowatts. The steam is taken from the boilers at a pressure of about 145 pounds, and it exhausts into ordinary jet condensers after having passed through a closed heater. The condensed steam and the circulating water are removed from the condenser by the ordinary bucket air pump. The proposition, as I understand it, would be to run the McIntosh & Seymour engines on 15 pounds back pressure, and to utilize this back pressure in driving a low-pressure turbine. Inasmuch as the steam engines now in use in the station are compound, this would amount to making of each engine a triple-expansion engine whose third cylinder would be replaced by a turbine. The combination is an entirely practical one and would not present mechanical difficulties either in building or in operation.

It has been stated that there is as much available energy in the steam below 15 pounds as between 145 and 15, or, putting it more briefly, there is as much energy in steam below the atmospheric pressure as above, in the ordinary stations. This is probably true, although not at once apparent to those who have no technical training in the use of steam. It is not so difficult to understand, however, when one considers that the energy of steam is represented by the product of the pressure and the volume (not by pressure alone). When the steam is at high pressure, the specific volume is necessarily much smaller than at low pressure. Roughly speaking, the volume may be said to be inversely proportional to the pressure. This being true, one can see that it would be entirely possible for the volume multiplied by the pressure above the atmosphere to be practically the same as the volume multiplied by the pressure below the atmosphere.

Determining Possible Economy

In order to determine with fair accuracy the possible economy with the combination suggested above, I ran one of the 500-kilowatt engines under three back pressures: first, as great a vacuum as was possible to obtain by speeding up the air pump; second, with a very moderate vacuum; third, on the atmosphere. It was not possible to weigh the feed water used under these different conditions. There are enough data available from the test made several years ago, in connection with the indicator diagrams taken in the above test, to determine within a very small per cent. of error the amount of steam used per indicated horsepower per hour. This was done, and a combined diagram made of the third case, in order to figure out the amount of energy available for the steam turbine.

During the run the exhaust steam from the air pump and feed pump was carefully weighed, in order to determine the expenditure for the auxiliaries. While the main engine was on the atmospheric pressure, of course there was no exhaust of steam from the air pump. It will be noticed that with the greatest vacuum—namely, 27 inches—the indicated horsepower developed by the engine was 803; with the vacuum of 23.3 inches, the indicated horsepower was 836, and with atmospheric exhaust, amounting to 16 pounds back pressure, it was 1001. These

figures may seem paradoxical, inasmuch as one naturally supposes that less power is developed by an engine when exhausting on the atmosphere, but in this case the cutoff naturally responded to the greater demand for steam, and consequently the power was increased in proportion to the demand at the switchboard. Furthermore, I purposely had the load increased during the atmospheric exhaust, in order to show that it was entirely possible to run the engine with an overload. It will be noticed in the last line that there is no gain by increasing the vacuum beyond 23 or 24 inches with the present arrangement in the station, inasmuch as the amount of steam used by the auxiliaries offsets the gain in the engine. The steam per kilowatt-hour is set down as 22.26 with 27 inches, 22.24 with 23.30 inches and 32.60 with atmospheric exhaust. This includes not only the steam expended on the main engine, but also the steam used on the auxiliaries, and is practically the total outlay of steam per kilowatt for the station, as represented in the three conditions attached.

DATA AND RESULTS OF TEST

Back pressure (pounds per square inch absolute)	1.5	3.3	16
Indicated horsepower	803	836	1,001
Kilowatts	540	563	673
Pounds steam per indicated horsepower	13.21	14.10	21.58
Pounds steam per kilowatt	19.64	20.96	32.07
Pounds steam per indicated horsepower, including air and feed pump	14.97	14.96	21.94
Pounds steam per kilowatt, including air and feed pump	22.26	22.24	32.60

The greatest amount of power thus obtained from one of the 500-kilowatt engines was 1001 indicated horsepower, or 673 kilowatts at the switchboard, which was obtained on 32.07 pounds of steam per kilowatt-hour, excluding the auxiliaries. A combined diagram was made, in order to calculate with some accuracy the amount of power available for a low-pressure steam turbine in case the steam were turned into the nozzles of such a turbine instead of being thrown away into the atmosphere. This power would, of course, be obtained without further expenditure of steam. It amounts to 1069 horsepower, to be added to the 1001 developed in the cylinders. The output with a steam turbine would, therefore, be 2070 indicated horsepower, or 1392 kilowatts, as against the normal output of 500 kilowatts, for which the engine was designed. A very great expansion of power is, therefore, at once apparent, so that there would be no question of the advantage of the turbine for the purpose of expanding the power with the present machines in the station. This increase is simply for one engine and would represent for the whole station the same proportionate increase on 4500 kilowatts. The total output of the station could therefore be doubled with ease by simply adding two or three low-pressure turbines.

When it comes to the actual expenditure of steam per horsepower with the exhaust turbine added, it must be remembered that there is no further expenditure of steam for the total power than was expended in the main engine exhausting into the atmosphere. The amount of steam, therefore, per kilowatt would be 15.51 pounds per hour, exclusive of auxiliaries, or 16.77 including auxiliaries. The allowance for auxiliaries here is the maximum of what was obtained on the run for a vacuum of 27 inches. It probably represents very closely what would have to be expended to provide for the vacuum against which the steam turbine would have to work. The amount of steam expended per kilowatt-hour for the 500-kilowatt engines, as now running, is 22.24 pounds including auxiliaries. The net saving would, therefore, be 5.47 pounds per kilowatt-hour. This represents a net gain by the introduction of a low-pressure turbine of 24.60 per cent. With this gain in economy, the output of the station could be increased from 4500 kilowatts to about 6000 kilowatts by the addition of one or more steam turbines without the expenditure of a dollar for additional boilers or coal; furthermore, the doubling of the station capacity, mentioned in the preceding paragraph, could be accomplished with only 50 per cent. increase of boiler capacity.

OPERATING COSTS

The cost of current during the past year was 2.75 cents per kilowatt-hour at the switchboard. Of this, 0.69 cent went into coal, and the percentage saving above indicated would simply be on the coal. This amounts to a saving of 0.17 cent per kilowatt at the switchboard and reduces the above 2.75 cents to 2.58 cents. There would be some change, of course, in other items consequent upon the introduction of the steam turbine; for instance, the cost of water would probably be reduced; the cost of wages would not necessarily change; the repairs to the station would probably increase, although this would depend upon the type of condenser used. There would also be an increase of expenditure due to the interest on the new plant. The steam turbine, pumps, condenser, and all parts necessary to keep the turbine running successfully would probably cost $25,000, the interest on which could be put at $1250. The saving in the coal above represented by 0.17 cent per kilowatt would be about $10,220. Deducting from this $1250, we have the net saving in dollars per year as $8970, with the present output, provided the introduction of the turbine did not introduce elements of complication. This question is one which can only be fully and positively answered by the use of the turbine. At present it can be answered by experience with high-pressure turbines and a few low-pressure turbines installed in connection with cooling towers. To my mind the use of a turbine in connection with a steam engine presents no difficulty whatever, and the only trouble I should anticipate would be in connection with maintaining a vacuum. It is necessary, in order to realize the fullest economy from the steam turbine, to carry a vacuum greater than 28 inches. The makers of the turbine prescribe 28 inches. This probably cannot be produced with the vacuum plant as now used in the Cambridge station, and the introduction of a low-pressure turbine would therefore compel the use of better condensing apparatus.

The Intelligent Use of Boiler Compound

BY W. D. RANNEY

Is there such a thing as the intelligent use of boiler compound to prevent the formation of scale? Feed waters vary considerably, but the two greatest enemies of clean boilers are the carbonates and sulphates of lime, as magnesia, mud and other suspended matter do not adhere to the tubes or boiler plates to any extent, but will generally wash out unless baked on.

A good hot-water heater and a pint of phenolphthalein are all that are required, with the use of soda ash, to keep boilers free from scale, the amount of water evaporated each hour being easy to ascertain. Nothing will compare, in price or efficiency, with soda ash intelligently used and the test water being taken from the steam drum instead of the heater.

Our boilers evaporate from 3000 to 3500 gallons of water every hour for 24 hours, and 80 pounds of soda ash keep them in working condition, with a thorough washing every 30 days. Soda ash at 1¼ cents per pound and 80 pounds every 24 hours for 3000 gallons per hour, make an attractive proposition.

A very small portion of scale-forming matter even gets to the boilers, because it is mostly precipitated by the action of the soda ash in the heater and flushed into the sewer every three hours, day and night.

Our feed water contains over 36 grains of scale-forming matter per gallon, and is the hardest kind of well water, but we have used nothing but soda ash for about six years with the exception of the tube cleaner twice each year.

On October 27 a derrick and a boiler which was being hoisted by it fell from the tenth floor of the 16-story building being erected on the site of the old Everett house, corner of Seventeenth street and Fourth avenue, New York City. The location of the boiler was being changed, when a cable broke, causing the derrick to collapse, and both derrick and boiler fell through the elevator shaft to the basement.

The Plunger Hydraulic Elevator

The "Standard" Plunger Elevator; Principal Difference between This and the Otis Types; Valve Construction and Operation

BY WILLIAM BAXTER, JR.

The plunger elevator made by the Standard Plunger Elevator Company differs in many details from the machine made by the Otis company. The principal differences are in the construction of the valves, and their location in the piping system connecting the lifting cylinder with the pressure tank. The general arrangement of the valves and piping is shown in Fig. 281, which is an elevation of the entire elevator apparatus. The valves are contained in two horizontal cylindrical chambers, one placed above the other, as shown. The upper cylinder contains the main operating valve and the pilot valve, the latter located at the right-hand end. The lower cylinder contains the two automatic stop valves, the top stop valve being in the left-hand end and the bottom one in the right-hand end. From the center of this chamber a pipe runs to the upper end of the lifting cylinder. The two valve chambers are connected with each other by two vertical pipes on opposite sides of the center, one for conveying the pressure water from the main valve to the lifting cylinder and the other for conveying the discharge water from the lifting cylinder to the discharge tank.

The pressure water enters the upper valve chamber through the supply pipe on the left, and passing through the main valve flows down through the left-side pipe connection to and through the top automatic stop valve and into the pipe that leads to the lifting cylinder, and thus forces the plunger and the car upward. On the down trip the water returns from the lifting cylinder to the lower valve chamber, and then passing through the down automatic stop valve on the right enters the right-side pipe connection that leads to the main valve chamber, and passing through the main valve reaches the discharge pipe. In the Otis machine, it may be remembered, the automatic stop valves are placed in the pipe lines outside of the main valve, so that the pressure water passes through the top automatic valve before it reaches the main valve; and when the water is discharged as the elevator runs down, it first passes through the main valve and then through the down automatic stop valve. In the Standard elevator the arrangement is just the opposite of this, the pressure water passing through the main valve first and then through the top automatic stop valve, thence flowing into the cylinder; from the cylinder it flows through the down automatic stop valve and then through the main valve. One arrangement is as good as the other, and neither one would be improved or injured by changing it to the other arrangement.

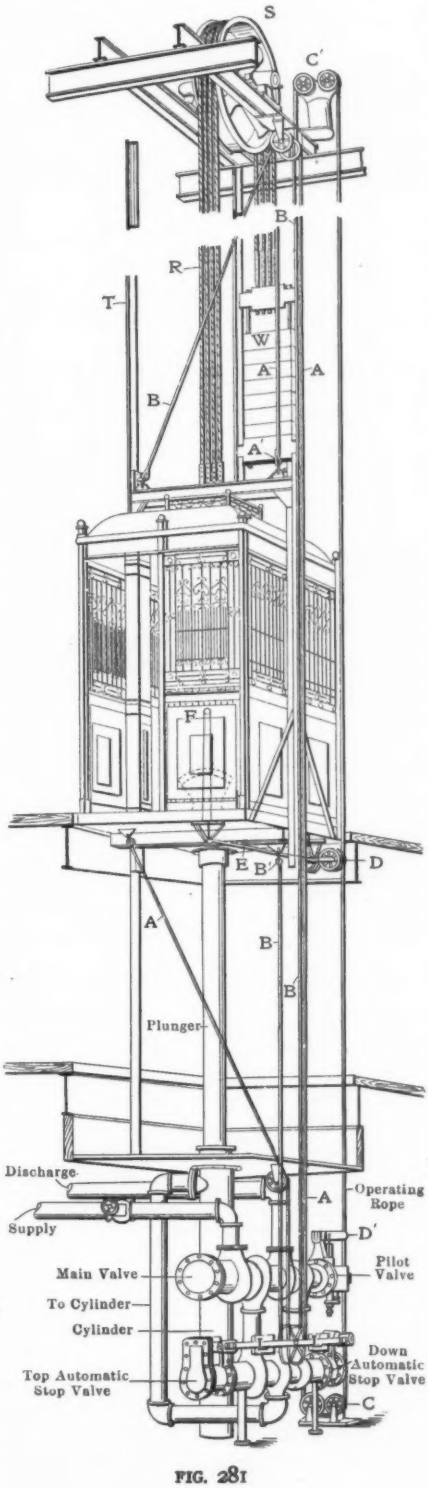


FIG. 281

In the Otis plunger the automatic stop valves are actuated by stationary or standing ropes, the upper ends being fastened to the overhead beams of the elevator well, and the lower ends to the valve levers. In Fig. 281 the stop valves are actuated by running ropes, the ends of which are fastened to the top and bottom of the elevator car. The rope *A*, which is attached to the under side of the car on the left-hand side, runs down to and around a sheave mounted on the end of the lever *L'* that actuates the down stop valve. From this sheave the rope runs up to the top of the elevator well to and around a sheave, and then runs down to the top of the car to which it is fastened on the right-hand side. The rope *B* is secured to the under side of the car on the right, at *B'*, and then runs straight down to and around the sheave on the end of the lever *L* of the top stop valve, and thence up to the top of the elevator well, over a sheave there and down to the left side of the top of the elevator car, where it is made fast. From this arrangement of the ropes it can be seen that when the car runs down the down-stop rope *A* will draw up the lever *L'*, and when the car runs upward, the rope *B* will draw up the lever *L* of the top stop valve. The distance through which the levers *L* and *L'* are raised by the ropes can be varied by shifting the left-hand points of attachment of the ropes on the car in one direction or the other; shifting them farther to the left, as the drawing is made, increases the movement of the levers.

The pilot valve is operated by a standing-rope system, the ropes passing around sheaves *C* at the bottom of the well and other sheaves *C'* at the top. These latter sheaves are mounted on a frame that is forced upward by a spring contained in the cylinder shown below the sheaves. This maintains the proper tension on the ropes. The ropes pass around the sheaves D carried in a frame mounted on the shaft *E* under the car, and to this shaft the car lever *F* is secured; by moving this lever in one direction or the other the pilot-valve lever *D'* is raised or depressed, and the car travel is thereby controlled.

Construction and Operation of Valves

The construction and operation of the valves of the system shown in Fig. 281

are indicated by Fig. 282, which is a sectional elevation parallel with the axis of the valve rods, and shows the general construction and positions of all the valves. The main valve consists of five pistons *Q*, *R*, *R'*, *T* and *T'*, the first of which acts as a motor to move the valve, in the same way as in all the other pilot-valve constructions described in previous articles. The main valve is shown in the closed or stop position. The automatic stop valves in the lower cylinder are indicated by the letters *Y* (the down stop) and *Z* (the up stop).

In all types of pilot valve, the movement of the main valve acts to return the pilot to the closed position, and in most of the reaches the closed position when the movement of *Q* to the right will stop as no more water will flow into the space *M C*. If the pilot-valve lever *X* is depressed, the water in space *M C* will flow out through the pipe *P* in the direction indicated by the dotted arrows and upon reaching the pilot valve will pass through it and into the pipe *E''*, which leads to the main discharge pipe *E'*. The movement of the rack *U* will then be in the opposite direction and the pinion *P'* will be rotated so that the pilot valve will be raised to the closed position.

When the main valve pistons are moved to the left by the downward movement of the lever *X*, the ports of the supply pipe *S* car at the top floor. On the down trip the down stop valve *Y* will be opened, and as soon as the main valve is shifted to the right far enough to cause the piston *T* to uncover the ports opposite the pipe *E*, the water will flow out of the cylinder through the pipe *S''* into the pipe *E*, through the main valve to the pipe *E'*, and the car will run down. When it approaches the lower floor the stop valve *Y* will be slowly closed by the lifting of the lever *W*, being closed entirely when the car reaches the level of the lower floor.

Fig. 282 is one of the early designs used by the Standard company, and is considerably different from the valves used with elevators installed at the present

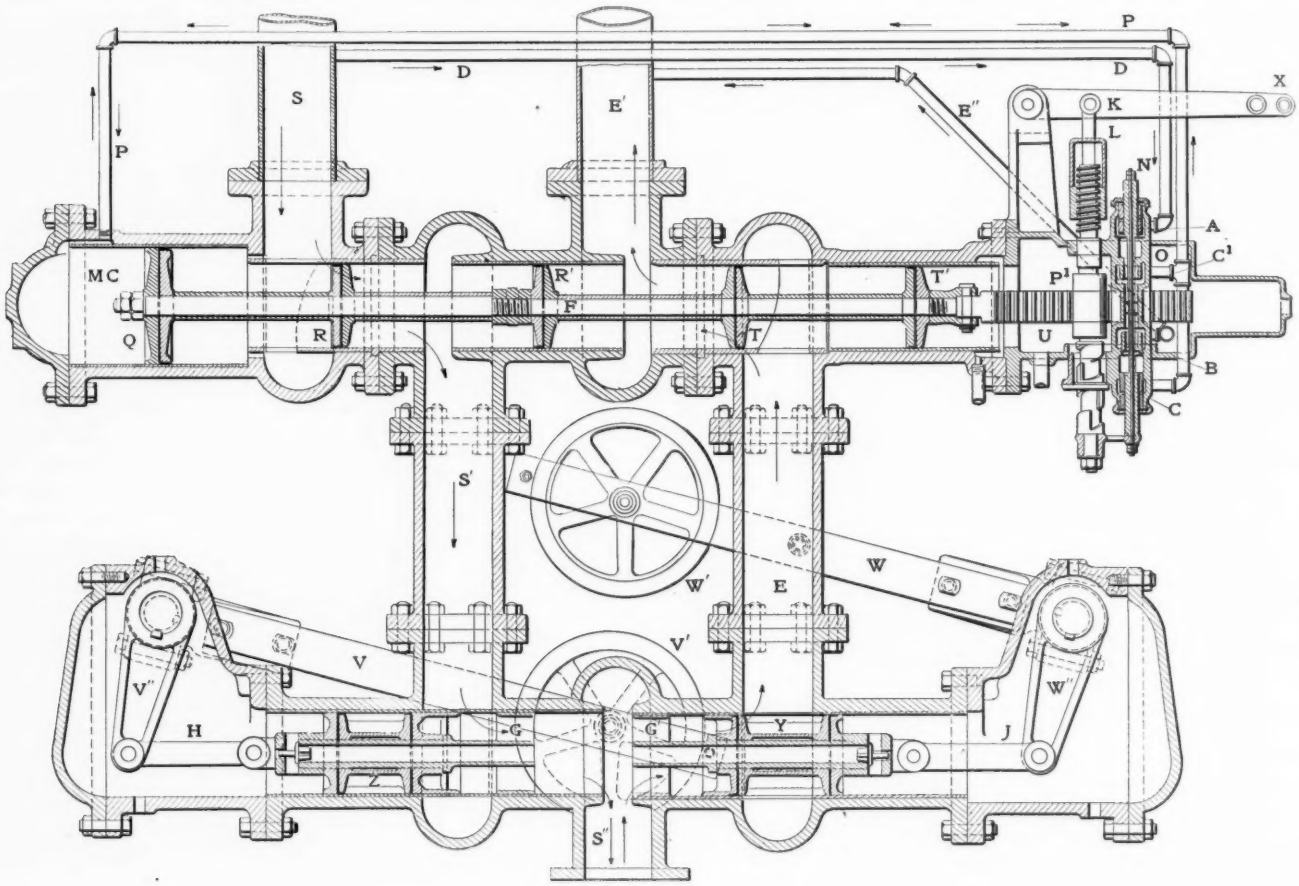


FIG. 282

arrangements thus far shown the way in which this result is produced is easily seen, but in this valve it is not so apparent. The part *U* at the right-hand end of the main valve stem is a rack, and *P'* is a pinion meshing with this rack. If the pilot-valve lever *X* is raised, the connecting rod *K* will lift the nut frame *L* and thereby raise the pilot valve, allowing water to flow in from the main supply pipe *S* through the pipe *D;* passing through the pilot valve, it flows through the pipe *P* to the end *M C* of the main valve chamber, where it forces the piston *Q* to the right. This movement will rotate the pinion *P'* so as to run the screw at the upper end out of the nut *L* and force *P'* down and with it the pilot valve, until the latter will be opened by the piston *R* and water will flow through as indicated by the arrows, to the pipe *S'* and thence through the uncovered ports of the lower chamber to the pipe *S''* and to the cylinder, causing the car to run upward. The top stop valve *Z* will be in the open position as shown, and if the car is at the lower floor the down stop valve *Y* will be closed. As soon as the car begins to move upward, the lever *W* of the down stop valve will descend and gradually open the valve *Y* while the car is rising through the first ten or fifteen feet. When the car reaches the top of the well, if the operator does not move the car lever to stop the car, lever *V* will be gradually raised and the stop valve *Z* will slowly close and stop the time. The latest design of valve is shown in the drawings Fig. 283, which gives a plan view and a sectional elevation. The pilot valve is substantially the same as in Fig. 282, but the main valve is materially different and the automatic stop valves are turned around so that the cranks that move them are in the center, instead of at the ends of the valve chamber. The main valve consists of four pistons, and the force for moving them is obtained by making the piston *T'* of smaller area than the other three, so that this piston virtually takes the place of the piston *Q* in Fig. 282. The flow of water through the valves is as indicated by the arrows; the port *M* at the center of the automatic stop valve chamber leads to the lifting cylinder.

The two levers *W* and *V* which move the automatic stop valves swing around the shaft *A* but only the lever *V* is keyed to it. The other lever swings freely around the shaft *A* and through the gear segments *D'* and *D''* moves the shaft *B* and thereby actuates the stop valve *Y*. This arrangement of the levers is made somewhat clearer by looking at the plan view in Fig. 283, which also shows the actual position of the pipe connections between the pilot valve and the main valve chamber, and as these are lettered the same as in Fig. 282, the direction of flow of water through then can be readily understood.

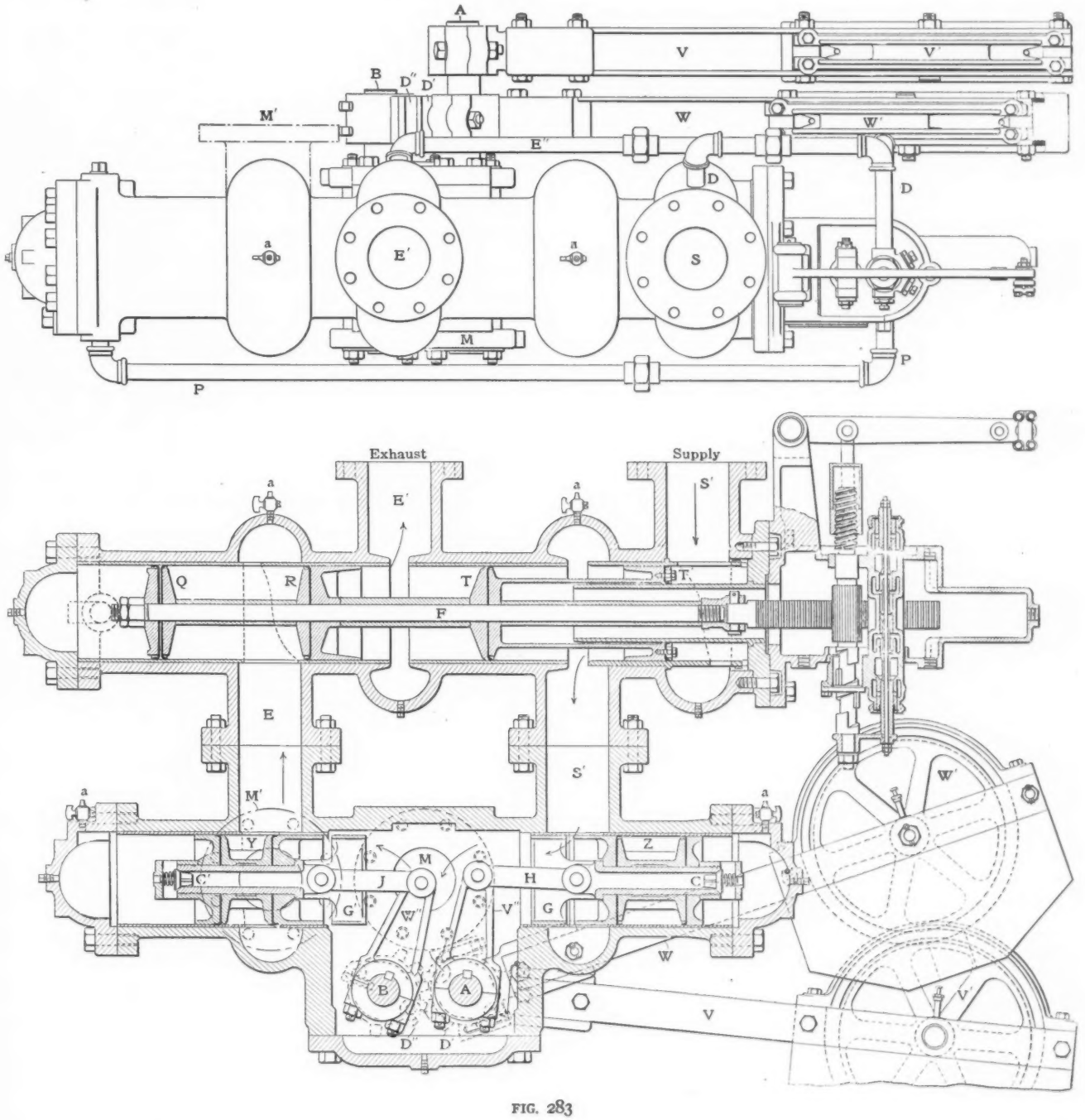


FIG. 283

Each stop valve is provided with a cylindrical extension marked *G G'*, the same as in Fig. 282, and this extension acts as a throttle when the valve moves far enough backward. In Fig. 283 the valve *Y* is shown closed and valve *Z* open; through the latter water passes through a port that separates it from the extension *G*. If the valves are in perfect working order, the valve never moves farther away from the center than the position in which it is drawn, but if the rope that actuates the lever *V* should break, the lever would drop and carry the valve *Z* away from the center until its end touched the head of the valve chamber, and then the throttle *G* would cover the ports leading in from pipe *S'*. From this it is evident that the throttles *G G'* are simply safety devices that never come into action except in the case of some disarrangement of the ropes that lift the levers *V* and *W*; they are not made a tight fit, but are loose enough to permit water to leak through them fast enough to enable the car to move very slowly, so that if the actuating rope should break when the car is half way up the elevator well, it would not be held there but would slowly run to the end of the trip.

The valves *Y* and *Z* are made with an opening through the center so that water may circulate through them between the end spaces and the crank chamber at the center of the valve chamber. This construction is provided so that the valves may move freely. In each one of these openings a check valve *C* or *C'* is provided to prevent the valve from moving

away from the center so rapidly, if the rope that actuates the lever should break, as to cause the throttle to stop the flow of water too suddenly. The check valves are so proportioned that when the water flows through them to the space back of the stop valve, the opening is large enough to afford it free passage, but when the water is forced out of this space, it has to pass through small holes made in the check valves and these are of such size that the weight of the lever V or W cannot move the throttle G or G' back over the ports so rapidly as to produce a too sudden reduction of the car speed.

In Fig. 283 it will be noticed that an outlet M' is shown in broken lines. This outlet is not always used, but when used its object is to economize pressure water, and also to prevent the plunger from rising above the water in the cylinder if a too rapid stop is made on an up trip.

The Quality of Steam

By William F. Fischer

Mr. Spooner, in illustrating the principle of operation of a calorimeter as described in his article in the September 1 issue, page 348, gives the following: "Boiler-gage pressure 85 pounds, 100 pounds absolute, and allowed to expand to the pressure of the atmosphere (14.7 pounds per square inch) through a ⅛-inch orifice in the calorimeter doing no work." The final temperature of the superheated steam, or the steam expanded from 100 pounds absolute, to the pressure of the atmosphere is given as 452 degrees, whereas the temperature of the steam at boiler pressure is only 327.625 degrees. This indicates a considerable rise in temperature, and Mr. Spooner is evidently in error in his calculation, which I will show.

By referring to the steam tables in Kent, or almost any engineers' pocket book, a pound of dry saturated steam at 100 pounds absolute pressure is found in the column headed "Total heat in the steam above 32 degrees Fahrenheit" to contain 1181.8 B.t.u., and a pound of dry saturated steam at atmospheric pressure, 14.7 pounds absolute, is found in the same column to contain 1146.6 B.t.u.

For every pound of this steam at 100 pounds absolute as it is expanded to the pressure of the atmosphere, doing no work, as there is no resistance to overcome, 1181.8 — 1146.6 = 35.2 B.t.u. is liberated, which goes to heat the pound of steam at atmospheric pressure. Or, in other words, if we assume there is no loss in the calorimeter from radiation, the quantity of heat should be the same after passing through the orifice in the disk as it was at the boiler side of it. Therefore, a pound of steam at atmospheric pressure should contain the same number of B.t.u. as a pound of the steam at 100 pounds absolute pressure, in this case 1181.8 B.t.u., but 35.2 B.t.u. of this is in the form of superheat as mentioned above.

If we assume the specific heat of superheated steam at constant pressure to be 0.48, or in other words, at constant pressure 0.48 of a B.t.u. will heat a pound or dry steam 1 degree, the steam at atmospheric pressure will then be superheated 35.2 ÷ 0.48 = 73.33 degrees.

The temperature of this dry saturated steam corresponding to its pressure of 14.7 pounds per square inch is found in the steam tables to be 212 degrees Fahrenheit. Adding the superheat, we get 212 + 73.33 = 285.33 degrees Fahrenheit, which equals the temperature of the steam at atmospheric pressure, due both to its pressure and to the superheating effect of the 35.2 B.t.u. liberated per pound from the steam at the boiler pressure while passing through the ⅛-inch orifice in the calorimeter, in place of 452 degrees as given by Mr. Spooner.

For easy reference the above calculation may be put up in an algebraic formula as follows:

Let

t_2 = Temperature of the steam after expanding through the orifice in the calorimeter (in degrees Fahrenheit), or its temperature corresponding to its pressure plus the superheat in degrees Fahrenheit.

t_1 = Temperature in degrees Fahrenheit of steam at the reduced pressure. The temperature corresponding to its pressure only at atmospheric pressure, t_1 = 212 degrees Fahrenheit given in the second column of the steam tables.

H = Total number of B.t.u. above 32 degrees Fahrenheit in a pound of steam at the boiler pressure, or at the gage above the disk.

H_1 = Total number of B.t.u. above 32 degrees Fahrenheit in a pound of steam at the reduced pressure. At atmospheric pressure H_1 = 1146.6 B.t.u.

Then for dry steam, assuming no loss from radiation, and taking 0.48 as the specific heat of superheated steam at constant pressure,

$$t_2 = \frac{H - H_1}{0.48} + t_1$$

Substituting the above values we get

$$t_2 = \frac{1181.8 - 1146.6}{0.48} + 212^\circ = 285.33$$

degrees Fahrenheit.

All that has been said above refers to dry saturated steam. Suppose, however, the steam to contain 1 per cent. of moisture. Then before any superheating can take place this moisture must be evaporated into steam at atmospheric pressure. The heat of vaporization, or the latent heat of steam at atmospheric pressure is 965.8 B.t.u. (found in steam tables).

Therefore, evaporating the 1 per cent. of moisture would require

$$965.8 \times 0.01 = 9.658 \text{ B.t.u.}$$

per pound of steam, leaving only

$$35.2 - 9.658 = 25.542 \text{ B.t.u.}$$

available for superheating.

The superheat then becomes 25.542 ÷ 0.48 = 53.21 degrees as against 73.33 degrees in the previous case where the steam was dry. Similarly t_2 becomes 212 + 53.21 = 265.21 degrees as against 285.33 degrees with dry steam.

The degree of superheat can be worked out in a similar manner for other percentages of moisture. The following formula may be used giving the same results as above:

$$t_2 = t_1 + \frac{H - H_1 - L_1 \times M}{0.48},$$

where

M = Percentage of moisture in the steam,

L_1 = Latent heat of the steam at atmospheric pressure as above 965.8 B.t.u.

Considering the case above, and substituting the figures in the formula we get

$$t_2 = 212 + \frac{1181.8 - 1146.6 - 965\ 8 \times 0.01}{0.48} =$$

$$212 + \frac{35.2 - 9.658}{0\ 48} = 212 + 53.21 =$$

$$265.21 \text{ degrees} = t_2.$$

In testing for moisture the percentage of moisture in the steam may be found by the use of the following formula:

$$M = \frac{H - H_1 - 0.48 \times (t_1 - t_2)}{L} \times 100,$$

where

M = Percentage of moisture in the steam,

L = Latent heat of the steam at boiler pressure, or at the gage pressure above the disk depending on position of calorimeter in the steam line,

H, H_1, t_2, and t_1 are the same as above.

As an example, consider the case above, taking the figures as given, and taking t_2 as 265.21 degrees. It is required to find the percentage of moisture in the steam.

Therefore

$$M = \frac{H - H_1 - 0.48 \times (t_2 - t_1)}{L} \times 100 =$$

$$\frac{1181.8 - 1146.6 - 0.48 \times (265.21^\circ - 212^\circ)}{884} \times 100 =$$

$$\frac{35.2 - 25.5408}{884} \times 100 = \frac{9.6592}{884} \times 100 = 0.0109$$

per cent moisture = M, or, in other words, there is 0.01 part moisture to every 100 parts steam.

Practical Letters from Practical Men

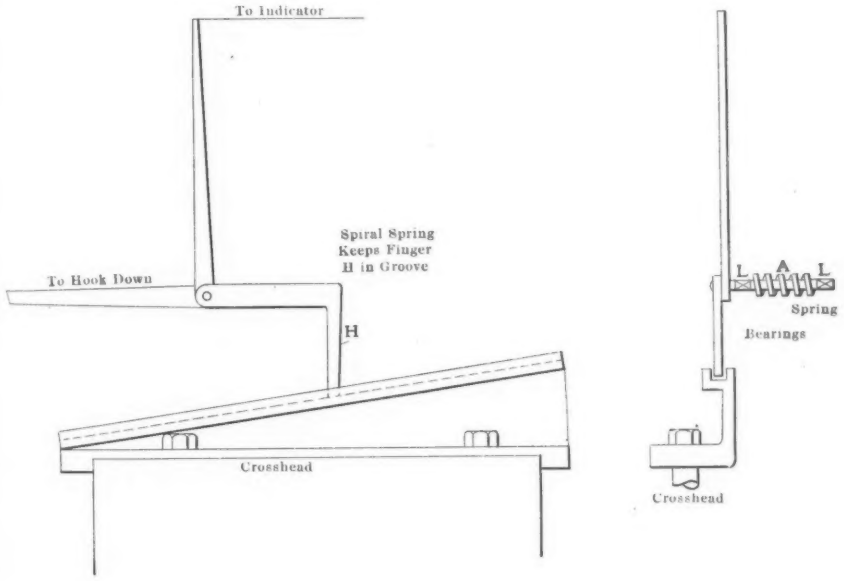
Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Indicator Reducing Motion

In a recent issue I notice a description of an indicator reducing motion got out by the American Ball Engine Company, which is similar to one I applied to one of its engines at the Gratan & Knight Manufacturing Company's plant at Worcester, Mass., while I was in charge of that plant a few years ago.

Being a little dubious about hooking onto a bolt screwed into the crosshead, I designed the reducing motion shown in the illustration, making it as light as possible and of tough bronze. It was finished up by a skilful machinist of our company.



INDICATOR REDUCING MOTION

The finger dropped through a small hole cut in the cover over the crosshead onto the incline plane. When not in use the top lever was drawn down horizontally and held by a hook. A spiral spring on the rock shaft kept the finger in contact with the incline plane and opposed hooking down. The incline plane was bolted to the crosshead as shown.

I see no need of the roller or small pulley they have added. In mine I avoided this complication. So far as I am concerned, anyone is welcome to use the idea, and for high speed I prefer it to any rig I ever used.

J. W. GRANT.

East Pepperill, Mass.

Steam Plant Piping Blunders

I was recently called to assist in the installation of a new power plant for an ice and refrigerating company. I was to work under the supervision of the mechanical engineer of the concern. While I was attending to the installation of the main engine and compressor, and the smaller auxiliary engine, the mechanical engineer was overseeing things generally, and the installation of the boilers and boiler-room equipment especially. When I had time to look over the work outside of my own limited sphere of activity, I found that the open feed-water heater had no automatic overflow valve or other device to care for the heater in case the regulating valve for the supply failed to work, so that should it at any time happen that the regulating valve failed to work, and the water level should rise in the heater above the exhaust opening, there would be nothing to prevent the flooding of the engine, and a probable serious breakdown. I called attention to this, and was told by the mechanical engineer that another plant he was familiar with was using a heater connected in this manner. I did not like the idea, and wrote to the makers of the heater, asking for their recommendations, and they advised that an ordinary low-pressure trap should be connected to the heater, as this was as necessary to the heater as the safety valve is to the boiler. With this I managed to get the changes made that I had recommended.

I found further that it had been planned to install a bypass for the exhaust steam from the engines, so that in case it should be desired to cut the heater out for any reason, it could be done. When I examined the bypass arrangement I found that there was a cutoff valve at the top so that it could be closed above the heater, and thus prevent exhaust steam from coming in from that direction, but at the bottom there was no cutoff valve. As steam will always go the easiest route, and in such cases as this, the easiest route would be through the heater to the atmosphere, when it was opened for cleaning or other reasons, a man would have a warm proposition on his hands should be wish to give his heater attention without a shutdown.

In this plant the exhaust is carried from the basement to the top of the fourth floor, and the pipe is reduced above the heater, so that the tendency of the steam to go the shortest route would be increased.

It is expected that we will take water from this heater at 210 or 212 degrees, and the boiler-feed pumps are set on a level with the feed-water heater, so that at best we will never have a head of over 30 inches. I cannot but feel that the man who takes charge of the plant after it is completed, will be able, after a short experience, to look back and say, as did one of old, that his "days were full of trouble."

When I got to the boiler-feed lines, I found no valves between the check valves and the boilers. I called the attention of the pipefitters to this, and was told the "boss" had laid out the work that way. I suggested that it must be an oversight, and that attention be called to it, and the foreman pipefitter went to the mechanical engineer and suggested the advisability of placing valves between the checks and the boilers. The mechanical engineer said that it was "six of one and half a dozen of the other," whether the check is placed between the boiler and the valve, or the valve between the boiler and the check.

In this same plant it became necessary to connect a blowoff line to a blowoff tank, and the line from the tank to the sewer crossed the exhaust line from the

engines on the same level, or nearly so. Instead of sacrificing the blowoff to the exhaust line, the exhaust line was sacrificed to the blowoff, so that there is a pocket about 10 inches deep to fill with condensation. Sometime a careless man will be in a hurry to "get her going" and away will go a few sections of good pipe, and maybe a few innocent people will be seriously injured.

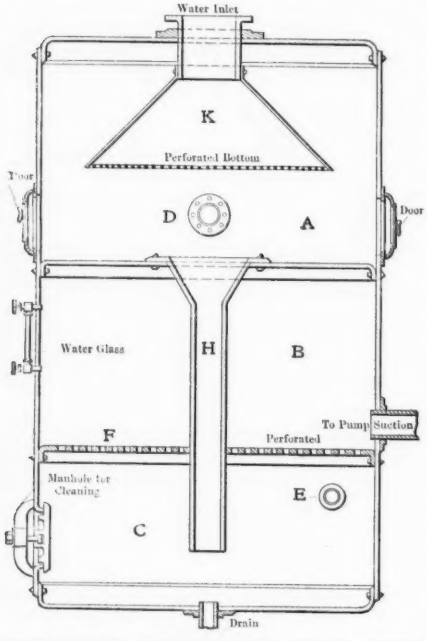
No man can be more competent to advise in matters of this nature than the man who has worked in grime and sweat to get through a siege of trouble, through mistakes that might as well have been avoided if the advice of practical men had been asked for and accepted at its proper value. When a man is called out at midnight a few times to help out of an emergency that mistakes have been responsible for, he is more likely to have his eyes open to avoid their repetition than the man who has never had this unpleasant experience. In this connection I may add that I believe that experience is, indeed, a dear school, but to the willing learner, is worth many times its cost.

WILLIAM WESTERFIELD.

Lincoln, Neb.

Making a Water Filter

In the September 15 number, L. W. Colvin asks for suggestions for making a water filter. Herewith is a sketch of a



FILTER MADE OUT OF AN OLD BOILER SHELL

filter which may be made out of an old boiler shell or tank. The tank is divided into three compartments by the two partitions shown. Water enters at the top into the inverted funnel-shaped piece in compartment *A*, drips through the perforated bottom and passes down through the pipe *H* to the bottom of compartment *C*, which is filled with coke, straw, or other suitable material. The water passes upward through this matter, and through the perforated head *F*, into compartment *B*, where it overflows to the pump suction.

Compartment *A* should be fitted with doors for cleaning out, and compartment *B* with a water glass. Compartment *C* must have an opening for filling that chamber with the filtering material, and should also have a drain pipe at the bottom. It would be well to put a connection at *E* in the chamber *C* so this chamber can be flushed in the reverse direction and the dirt washed out of the filtering matter.

The particular feature of this filter is that the water goes first to the bottom, where the dirt and heavier matter will settle, and then rise *upward* through the filter bed. If desirable, exhaust steam may be admitted at *D*, which will help to precipitate the dirt, etc., and at the same time the filter will act as a heater. A strainer in the inlet line outside the filter is desirable, and if used as a heater a grease extractor in the exhaust-steam inlet line would be a good thing. The hight of water in the chamber *B* could be controlled automatically by means of a float operating a valve in the inlet line.

E. S. HARRAR.

Fairport Harbor, Ohio.

Herewith is a description of a filter which we are going to build. It has not been tried yet, but we are confident it will answer the purpose. The discharge pipe from the pump, passing to the bottom of the filter, is increased to 6 inches at the top, the idea being to have the water move as slowly as possible. The water moves upward through the wooden-grate floor and through hay or excelsior.

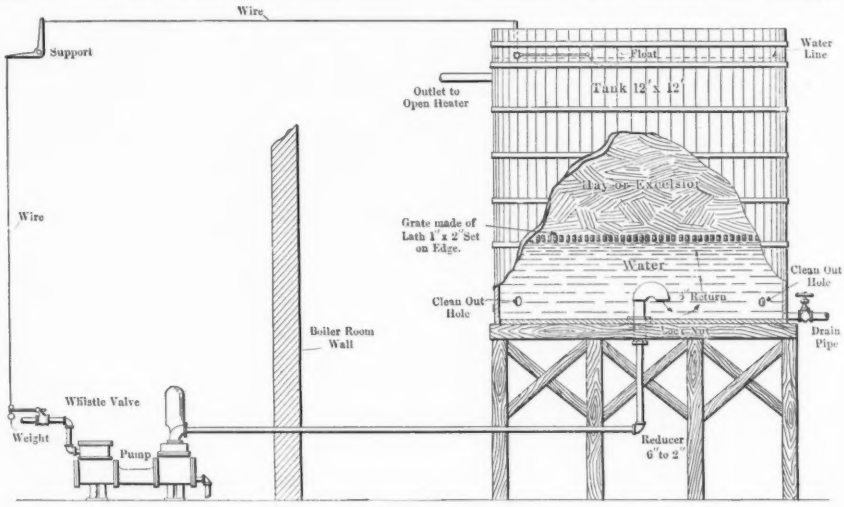
The tank should be large, to keep the water as quiet as possible. The hay is held down by weighted boards. A cold-water pump will be used to keep the filter full. As the water lowers, the float drops, and pulls the lever connected to a whistle valve, insuring a constant level without attention.

We also intend to have the cold-water pump exhaust into the filter through pipes, in order to keep the water from freezing in winter. The tank is 12x12, and for each 1000 gallons of water we intend putting in 2 pounds of lime and 1 pound of soda ash.

W. E. TURNER.

Wilmington, O.

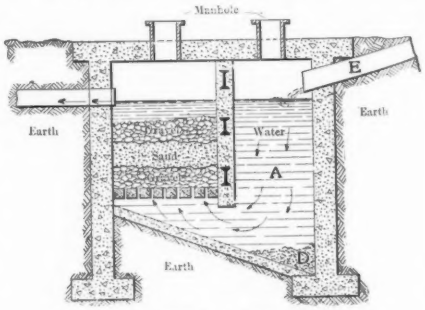
The accompanying illustration shows how a filter may be made of concrete. The middle slab should be reinforced



A PROPOSED WATER FILTER

with iron bars supported by the side walls, and there may be one or two piers in the middle. There should be sufficient room for the water to pass freely under it. As the bed of filtering material becomes gradually clogged by the accumulation of refuse, and checks the flow of water, it will be necessary to reverse the flow. The bottom of the chamber is provided with a pocket, in which sediment may gather, to be removed at a manhole made from large sewer pipe.

The water enters the chamber *A*, through the pipe *E*, and deposits any solids that may accompany it into the pocket, as shown at *D*. The water then flows upward through the sand in chamber, which clarifies it. There should also be a manhole in the top of the chamber to put in the gravel and sand.



WATER FILTER MADE OF CONCRETE

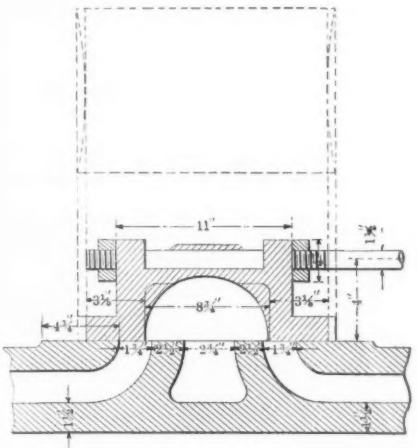
A 6x8-foot filter will be large enough to filter 10,000 or 15,000 gallons per day, and it will take about one yard of gravel and one-half yard of sand for the filtering material.

FELIX HAGAN.

Florisant, Mo.

Lead and Compression

In one of the recent numbers is an editorial on "Lead and Compression." I agree with the writer, and to show how good a valve may be constructed with lead and very light compression, I will describe the best valve (without Meyer's cutoff) that I ever made. It is an oddity, as will be seen. The little rectangle at the bottom is the "Sickels" patent graduated lead. The edge is not a straight line, but a curve ¼ inch wider than the line at the center, thus allowing only a very small opening, which gets larger as the valve moves over the port face. With this valve there is no possible hammer blow from lead, at any speed.



VALVE TRAVEL LEADING EDGE OF PORTS 15 INCHES

These were valve improvements fifty-six years ago. The engine had a 24-inch bore by 4-foot stroke, and could be run at any speed in absolute silence. The valve travel was 6.25 inches, the steam head was ⅛ inch, and the exhaust clearance on the central position ½ inch at each end. On the forward stroke the admission was 64 per cent., release 85 per cent., and compression 0.06 per cent. On the backward stroke the admission was 56 per cent., release 80 per cent., and compression 0.08 per cent. The clearance was ⅜ inch at each end, cold.

Although the release is early, the big lap made the compression small, as it always ought to be. It can be seen that both exhausts are open at the same time. As for lead, all it is wanted for is to get the full boiler pressure on the piston, just as it begins to move. In all slow-speed engines, up to about 80, lead is not *apparently* wanted, but I saw in Providence, R. I., a mill get within an ace of destruction because of a conspirator-tinker, who (on pretence of an experiment) slipped the eccentric so that the lead was 2 inches late, and the shock made the whole mill tremble.

High-speed engines must have not only lead, but large, smooth interiors in the valves and pipes, or enough steam will not get into the cylinder.

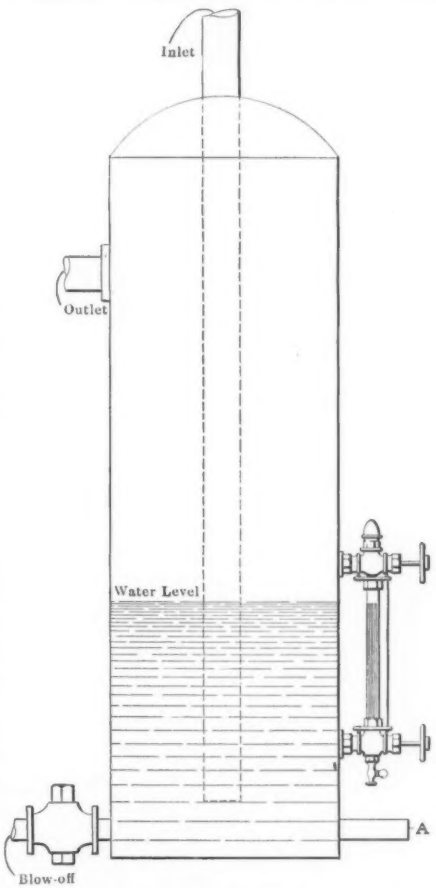
I learned a curious secret from D. K. Clark's "Railway Machinery"; that with rapid-fire engines, clear and smooth pipes and a short cutoff, it is easy to have from 2 to 5 pounds pressure on the piston above that in the boiler. But at least 160 pounds pressure is required, 250 revolutions and a 16 per cent. cutoff to get 3 pounds; for that is what the writer knows positively. You cannot have big compression in that kind of motor, as there is no time then for fooling.

PETER VAN BROCK.

Jefferson, Ia.

Explosion of Air Compressing Systems

W. E. Crane makes some interesting comments on page 542 of the September 29 number, regarding the explosion of air-compressing systems. His idea of having a reservoir partly filled with water, through which the air must pass to reach the distributing system is good, but my experience indicates that it will not extract all the oil, or entirely prevent carbonizing. I think, however, that if the reservoir which I used had been larger, it would have assisted materially in the final result.



RESERVOIR FOR AIR-COMPRESSING SYSTEM

The sketch shows the arrangement used. I had the pipe *A* connected with my boiler-feeding system, which carried a pressure in excess of the air receiver, so the water in the receiver could be blown down and renewed frequently, but the water from the wells in which the air was used for pumping showed oil contamination and the small air-feed pipes close to the receiver gradually closed up with carbonized oil and had to be taken down and cleaned at intervals. These troubles continued as long as we used nothing but oil as a lubricant for the air cylinders. This receiver was about 20 inches in diameter and 72 inches high, with 5-inch air-pipe connections, the compressor running single-stage, with no intercooler between the compressor and receiver.

In view of the fact that gas explosions in air-compressing systems continue to occur quite frequently, even in some of the larger and better equipped plants, it would seem to the writer that the utmost publicity should be given of all the direct and indirect causes as far as known, and also all the different remedies tried by engineers and others in charge of these plants, with the actual results obtained, to the end that greater safety of life and property may be insured.

L. L. ARNOLD.

East Greenwich, R. I.

Faulty Indicator Diagrams

A few days ago I took charge of a plant having a 16⅝x22-inch automatic engine. I soon noticed that it was working more or less on the gasolene-engine principle, having only one working end. I decided to put on an indicator at once, and the diagrams shown in Figs. 1 and 2 were what I obtained.

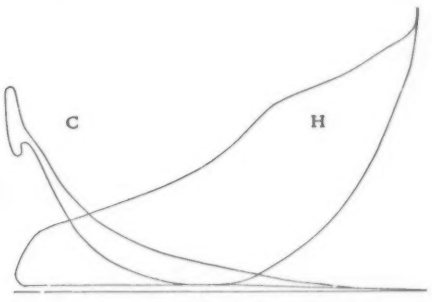


FIG. 1

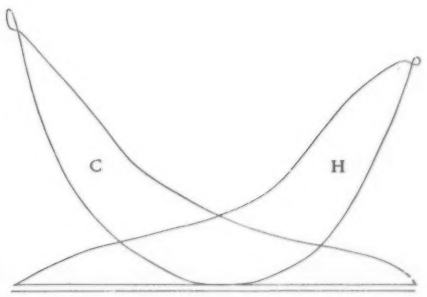


FIG. 2

What is the matter with those in Fig. 1, and what can be done to benefit the engine? They were taken after the day's run. The engine runs 210 revolu-

tions. The diagrams were taken with a No. 40 spring at 80 pounds boiler pressure.

J. ZEELENBERG.

Ottawa, Ill.

Engineering Problems

Some years ago, when trouble man of one of the large electrical manufacturing companies, I was sent to a large electric-lighting plant to calibrate and repair certain of the instruments on the switchboard, which were apparently out of order. On the lighting panels were three indicating and one recording instruments to take care of the load of this panel. The indicating instruments were an ammeter, a voltmeter and a wattmeter and the current coils on the wattmeter were supplied through current transformers. The voltmeter was provided with a potential transformer.

In making the tests, the calibrated instruments were inserted in series with the ammeter and in parallel with the voltmeter. In calibrating the wattmeter a portable wattmeter was inserted, with its current coil in series with the current coil of the ammeter, and its potential coil in parallel with the voltmeter. The readings were taken at all loads.

When the instruments had been calibrated and made correct, the superintendent of the station complained that there was an error. His explanation was that no alternating-current circuit had a power factor of unity, or even approaching unity, at moderate loads. This circuit showed from examination that the power factor was in the neighborhood of 95 at about half load. The circuit was for incandescent lighting through about three miles of cable, feeding a large district having a considerable number of 125-cycle transformers, the voltage of the circuit being 2200, the frequency 60 cycles. On following out the behavior of the circuit, it was noticed that at light loads the power factor was approximately 85. As the load increased, the power factor improved, until at little over half load the power factor was unity. At full load the power factor was approximately 90. What was the cause of this changed power factor?

In another case, a recording wattmeter was being tested, the current coils receiving power through series transformers, and the potential coils from the potential transformer. As the load on this circuit was constant, and it would have required considerable trouble to bring the leads of the testing instruments to the front side of the board, readings were taken from the testing instrument at the back of the board and then from the recording instrument on the front of the board. The instrument was checked up to within one-half of 1 per cent. This instrument was on the totality panel. The rest of the instruments on the circuit were correct.

On checking up the sum of the totals against the totality panel, it was found that they recorded about 4 per cent. more than the totality panel, and this occurred again and again. Further tests on the totality panel showed that this was correct. Tests on the rest of the instruments showed that they were correct. The potential transformer supplying current to this recording wattmeter had in its circuit three other instruments. What was the cause of the error, which amounted to about 4 per cent.? This error was found and corrected.

I should like to see what the ideas of other readers are, with reference to these two problems, and will furnish my explanation for them if a correct explanation is not forthcoming.

HENRY D. JACKSON.

Boston, Mass.

Low Compression Saves Coal

I am inclosing herewith a pair of indicator diagrams taken form our cross-compound condensing engine, under ordinary, everyday conditions. This engine has been in practically constant service since June, 1902. Our regular weekly run is from 7 a.m. on Monday to 6 a.m. on Sunday, and we do this fifty-one weeks in the year.

There has been much discussion of the question of compression, and I wish to add my experience to what has been published. It will be noticed that while the low-pressure diagram shows practically none, the one taken from the high-pressure side gives evidence of compression. I will say that having made many experiments with this engine, I am getting *smoother* running, and am consuming *less* fuel with the present adjustment than with any other I have tried.

M. E. COPLEY.

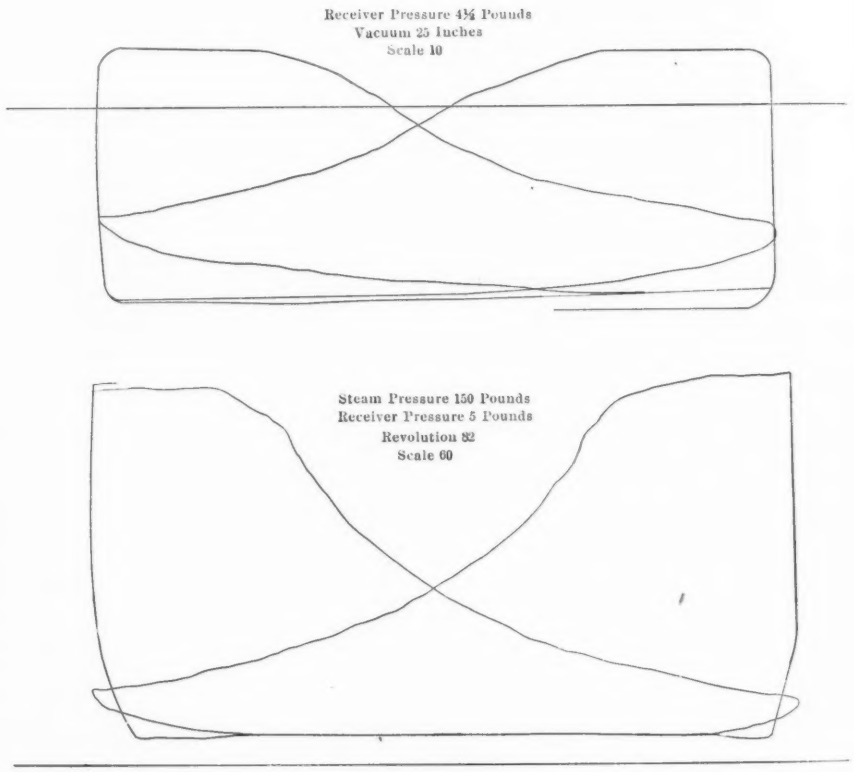
St. Louis, Mo.

Using Soft Coal Screenings

There are in this locality a number of plants using soft-coal screenings, but not on the ordinary grate. One plant of six boilers uses Youghiogheny screenings with automatic stokers and seems to have no trouble. Another plant of four boilers has used screenings with the Hawley down-draft furnaces for at least twelve years. The coal used runs about 14 per cent. ash, and is full of sulphur. An average of three dollars per ton is paid for it, which I think is too much. The latter plant runs continuously and the fires are cleaned every eight hours. The coal is wet quite thoroughly with a hose before firing, to help it to coke. It is fired lightly, spread evenly and disturbed as little as possible; in fact, the slicebar is only occasionally run in over the grate tubes to prevent the clinker from sticking.

WILLIAM AULD.

Milwaukee, Wis.



INDICATOR DIAGRAMS FROM CROSS-COMPOUND CONDENSING ENGINE

A Case of Bad Valve Setting

Under the above heading, in the September 22 number, A. C. Browne offers help to E. A. Stauffer, who asked for criticisms of his indicator diagrams, published in the August 11 number. It is evident from the following remarks of Mr. Browne that he does not thoroughly understand the relation of the angle of advance to valves in general. He says: "Inasmuch as Mr. Stauffer fails to state whether the piston valve mentioned is of inside- or outside-take type, or whether there is a rocker arm or crossover in the valve gearing, it is difficult to tell him just which way to move the eccentric." What does it matter whether the valve is direct or indirect, or whether the rocker arm forms a lever of the first class and reverses the motion, or not? One thing is certain, Mr. Stauffer's engine is fairly howling for an increase of angular advance, and if he will just forget all about "inside and outside takes" for a few minutes and devote his mind and muscle to advancing his eccentric around the shaft *in the direction the engine runs* until he finds the proper position, I am sure he will be a good many tons of coal ahead in the course of a few weeks. There would also be some valve-stem adjusting to do, as the diagrams show later admission on one end than on the other. Unless Mr. Stauffer is in the coal business, it will pay him or his employers to hire an engineer to set his engine right with a good indicator.

Several times I have been amused at men who run engines trying to memorize the different positions of the eccentrics relative to the type of valve to be set, when with a little study and a pencil compass they could fix it solidly in their common-sense department. We know that if a valve has lap and lead its eccentric is (or should be) set enough in *advance* of a line at right angles to the crank to give prompt admission, etc.; this holds good whether the engine runs over or under, or has a direct or indirect valve or gear. If one stops to consider he will observe that in the indirect type there is an opposite factor involved in some part of the make-up, and that to compensate for this an opposite position for the line at right angles to the crank must be taken. Then having mentally placed this right-angle line, advance the eccentric, in the direction the engine runs, the amount desired for proper lead.

The position of the right-angle line relative to the crank can be easily understood by a glance at Figs. 1 and 2, it being taken for granted that any "starter and stopper" knows its position under the usual conditions of running over with a direct valve and gear. In Fig. 1 the full lines indicate the position of crank, right-angle line and eccentric, under the most usual conditions, while the dotted lines represent the positions when the engine runs under, with direct valve and gear as before.

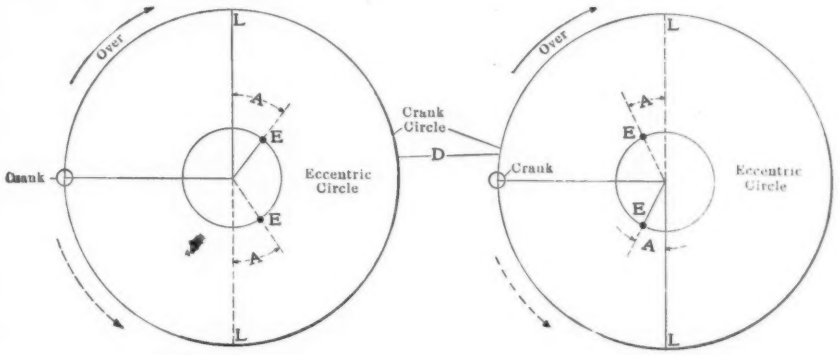


FIG. 1

FIG. 2

In Fig. 2 the full lines show the positions of the crank and eccentric when an indirect valve or gear is used, with the engine running over, while the dotted lines show the position of the same when the engine runs under.

The point I wish to emphasize is that in each of the above examples of valve setting the eccentric E is given the angular advance A ahead of the right-angle line L; hence, if an engine is "late" it is only necessary to increase the angle of advance A, and by taking more cards find the proper position for the eccentric, without wasting time and coal, wondering which way to turn it.

The only thing to memorize in this method is that if the valve in admitting steam has an opposite motion to the eccentric rod, then the right-angle line must be considered in an opposite position.

J. A. CARRUTHERS.

Bankhead, Can.

Reinforcement of Lap Joints

In the August 4 number, page 197, Forrest E. Cardullo has an article relating to the reinforcement of lap joints by means of an inside strap, which, I believe, will bear further discussion. The purpose of the portion of the original article by the writer, which is referred to, was to show the usual form of such joints and the method of calculating their strength; and the opinion of the writer regarding their usefulness, as stated in your editorial in the same issue, was the result of correspondence with the editor regarding the features of this particular type of joint, without reference to the article. The interposing of a strip between the strap and the shell, as advocated by Professor Cardullo, was suggested by the editor in this correspondence.

Now, in the first place, I do not believe that Professor Cardullo means literally what he says near the bottom of the first column on page 197, i.e., "The outer row of rivets passing through the outer lap of the plate (the lower row in each of the illustrations) does not take its share of the strain, on account of the elasticity of the strap where it bends over the edge of the inside lap. Consequently the joint is no stronger with the strap than it would be without it."

Admitting that the bend in the strap necessarily introduces a certain amount of flexibility, it will doubtless require considerable force to spring the strap. Each rivet in the outer row of a joint, as illustrated in Fig. 14, page 30 in the July 7 issue, acts against a section of the strap 5 inches in length, and whatever force is required to cause this section of the strap to spring, whether it is equal to the shearing or crushing strength of the rivets in the outer row or not, it would be necessarily added to the force required to cause rupture by any mode of failure which might occur along the inner rows of rivets, and it would, therefore, increase the strength of the joint by this amount, instead of being worthless, as stated by Professor Cardullo. It is the opinion of the writer that the increase would be equal to the shearing strength of the rivets in the outer rows, if the thickness of the strap was suitable for the rivet diameter.

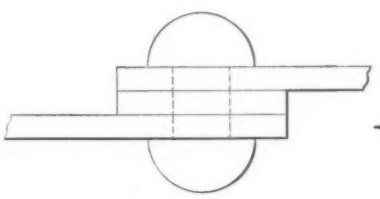


FIG. 1

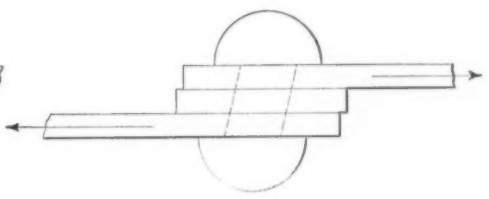


FIG. 2

Now, as for the remedy suggested of interposing a strip between the strap and the shell, it can be said that it certainly

would accomplish the desired result, but Professor Cardullo has apparently entirely overlooked another feature which this form of construction introduces, which in the opinion of the writer would be more likely to reduce the strength of the joint than the flexibility introduced by bending the strap. The strip of metal interposed between the strap and the shell being merely a loose distance piece and not attached to either member which transmits strain to the rivets in the outer row, the rivets in this row would not be in true shear, as shown in Fig. 1, but would probably assume a position similar to that illustrated in Fig. 2, before pulling off the heads or shearing, as the case might be. The force necessary to cause this distortion up to the point where failure along the inner rows of rivets would occur would, of course, add to the strength of the joint, but I believe that it would be weaker on the whole than the same joint with the strap bent. All that has been said above is only the personal opinion of the writer regarding the probable mode of failure of this type of joint, and I presume that Professor Cardullo's comments are similarly his opinions regarding the matter, but it is possible that he has the means at his command to investigate experimentally just what would take place in actual tests of such joints, and if he should make these tests he would be doing the engineering fraternity a real service by publishing the results.

In regard to the double strapping of the lap seam as suggested, while it would doubtless make a strong seam, the cost would probably be as great, or greater, as to cut off one end of the sheet and make a true butt double-strapped seam in place of the lap. It is not the intention of the writer that the above discussion of the strapped lap seam should be construed as advocating this form of joint in place of the butt double-strapped type where new boilers are to be built, but he believes that the strapping of the lap joint greatly reduces the possibility of the development of the so-called "lap-joint crack," and this method of strengthening the lap seams of boilers already constructed should not be condemned without actual test proves their unreliability.

S. F. Jeter.

New Haven, Conn.

Exhaustion of Ignition Batteries

If a gas engine exhausts its ignition batteries in six months, how long will it take the same engine to exhaust the same batteries running at double the former speed? There will be twice as many contacts, but the contacts will only be one-half as long.

R. Manly Orr.

Brantford, Ont.

Sparkless Commutation

In most cases, at least one-half of the causes contributing to brush sparking are rough and unsymmetrical brush and commutator surfaces. These can easily be prevented by the exclusion of all waxes, tallow, greases and paraffin, the latter of which is often used to silence noisy brushes.

The liberal use of kerosene applied with a cloth folded flat on the commutator of a machine when starting up cold, before the load is put on, will clean the commutator of all the carbon dust and foreign matter and also wash out the particles of copper dust which may have gathered on the brush faces. If the brushes are staggered properly and the spring tension is not too great there will be a wonderful improvement in the machine after two or three applications of kerosene. I find the use of kerosene on all kinds of direct-current machines up to 550 volts and operating at 25 per cent. overload for short periods to be entirely free from sparking. The hardness of the brushes makes no difference; where soft brushes are used the machine will require a little more attention. When copper-mesh brushes are used the kerosene should be applied and allowed to dry; the commutator should then be rubbed with a cloth saturated with a high-grade machine oil and the machine run at no load until the brushes work off the excess oil.

I have under my care, operating with continually varying loads, four 250-kilowatt 115-volt generators which have not had their commutators sandpapered or lathe-turned in three years. The brushes are surfaced or fitted to the commutator face once every eight months to insure sufficient contact area.

M. C. Saeger.

New York City.

Ability of a Steam Pump Under Stated Pressures

In regard to the reply published in the "Inquiries" department on page 554 of the September 29 number, in response to "F. C. J.'s" question as to the ability of a steam pump under stated pressures, I submit the following solution:

$$226 \times 90 = 20{,}340 \div 60 = 339$$

total pressure with no friction allowance;

$$339 \times 0.33 = 111.87$$

friction allowance;

$$339 - 111.87 = 227.13$$

working pressure.

The answer published does not work out right, as shown by the following:

$$226 \times 90 = 20{,}340 \div 60 = 305.66,$$

short 23.34 pounds;

$$305.66 \times 0.33 = 40.86,$$

only 0.13 per cent., instead of 0.33;

$$305.66 - 40.86 = 254.80.$$

W. S. Wright.

Beall's Mills, W. Va.

Favors Automatic Devices

In a recent number there was a letter by W. D. Ranney, in which he seemed to look rather unfavorably upon various automatic devices. The writer is an advocate of automatic devices, and places considerable confidence in them when they are under control of a competent engineer, because a competent man will see that they are always in good working order, and therefore are not liable to fail when conditions require their operation.

John C. Kahl.

Black Lick, O.

Buying Power and Making It

Leaving out the question as to whether it is advisable for manufacturers to buy power, I would like to look at the question from the engineer's point of view, and see what is the engineer's status in a plant which purchases power.

In manufacturing plants, as well as most isolated plants, the engineer has charge of the entire mechanical and electrical equipment, and the main generating unit requires the least attention of any apparatus under his control. If repairs are to be made on the engine, a repairman is sent for, while with the other apparatus the repairs are made by the operating force. In the majority of small plants this will be found to be the rule.

I think it is safe to say that any engineer taking charge of a new plant, no matter how expert he is with the indicator, can save more for his employers by putting his boilers, heating and ventilating system, pumps, etc., in good shape, than he can by setting the valves on the engine. In many plants the exhaust steam from the engine is sufficient for heating during the winter, and in such cases it is claimed by many that nearly as much steam would be required for heating if the engine were shut down. In hotels and office buildings, where elevators of all kinds, refrigerating plants and elaborate heating and ventilating systems are used, the main generating unit requires a very small part of the engineer's time.

When a plant which has been making its own power changes off and takes power from a central station, the engine is shut down and the boilers are used for what heating is necessary. While the engineer may be able to dispense with some of the help necessary to operate the steam plant, his cares and responsibilities are reduced very little, and he can be just as valuable to his employer as before, for everything must be run economically when buying power, as when it is made on the spot.

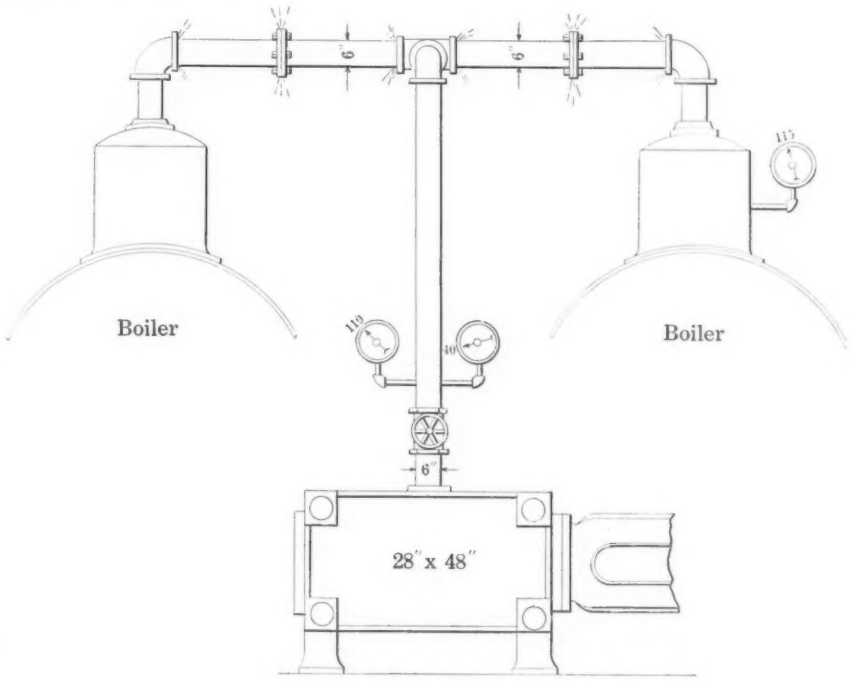
E. T. Reed.

Elmwood, Mass.

Waste in a Power Plant

In the power plant where I am employed, we have a good example of wastefulness due to the outgrowth of the steam lines. This is one of the many instances where a Corliss engine of a larger power has supplanted a 300-horsepower high-speed unit driven by two boilers having two 6-inch outlets connecting into one 6-inch tee, as shown in the illustration. There were also several flanges and fittings in the line between the boilers and the engine and leaks were strongly in evidence.

When a test was made of this steam line, we found that with a steam pressure at the boilers of 115 pounds, the highest pressure obtained at the cylinder of the engine was 110 pounds, which was



SHOWING THE LEAKING JOINTS

dropped to 40 pounds, as shown by the gage when the steam valve opened, the steam pipe being too small to supply the requirements of the larger cylinder. This is an example of steam piping that is quite low in efficiency, as it causes the engine to carry the steam farther out in the stroke than it should, and using more steam than it otherwise would, the expansion bein far less than if the pressure were maintained.

To make matters worse, every joint was leaking, as illustrated, and we lose enough by radiation when we are doing our best without the great loss from these bad joints. It seems quite common to find a small steam main connected to a large engine; here we have spent a great deal for a good engine and we have simply a throttling engine, as the steam is so much wire drawn that the expansive force is lost as well as the real benefit to be derived by the use of the Corliss engine.

C. R. McGAHEY.

Lynchburg, Va.

What Would You Do?

In the editorial in the September 24 number, under the above caption, are questions that will probably bring forth a variety of answers. In States and municipalities where there are rigid inspection and license laws, the ignorant engineer would get no farther than the examiner, where he would be "turned down." The intelligent man, after passing an examination, might become negligent and operate his boiler when he knew it to be unsafe. This man is worse than the employer who asks him to do so, because an employer, nine times in ten, does not know the danger of operating a boiler under unsafe conditions, and it is up to the engineer to show him wherein the danger lies.

Because a boiler has been run one year in an unsafe condition without an accident, is no reason why it should be run another. Still there are men who think it will, and who like to brag about the way they have run boilers.

I recently heard an engineer criticizing an inspector for condemning his boiler, because of a large bag. He went on to tell how he had run bagged and cracked boilers for years in sawmills, and he seemed to be proud of it.

There are men who daily risk their lives for large salaries, but I have yet to find an engineer who gets a salary large enough to warrant his risking his life for it.

If I were asked to operate a boiler I knew was in an unsafe condition, I would refuse, even if it cost me my position, and I do not think that those who were dependent on me would complain. I prefer to take a pick and shovel and dig in a sewer.

N. S. CAMPBELL.

Detroit, Mich.

The editorial, "What Would You Do?" presents a rather difficult question to answer offhand. What one might think he would do under a certain set of conditions or circumstances and what he actually would do are apt to be exactly opposite. If a man, with a family, were situated as described in the last example cited, he would probably stay and take the chances.

I have never worked for an employer who absolutely refused to remedy serious defects in the plant when they were properly pointed out to him. I have heard employers say that they did not want to go to the expense unless it was absolutely necessary. I have known them to "squeeze by" for a time with blowoff valves and other accessories where the danger was practically limited to one or two men who were thoroughly warned as to the danger, and where the chances of failure and serious results were reduced as much as possible by this prior knowledge. But it is hard for me to believe that a normal employer would allow such dangerous conditions to exist, if he had been duly warned of the impending danger.

And here is where the ignorant engineer referred to in the first part of the editorial, who allows these conditions because he doesn't know any better, comes in, and here, also, we get up against that almost universal fallacy of the human race, the endeavor to get something for nothing.

L. L. ARNOLD.

East Greenwich, R. I.

Boiler Tests

Not having seen the record of many boiler tests in recent issues of POWER AND THE ENGINEER, and thinking the same would be of interest to many of the readers thereof, I submit the following:

The objects of the test in this case were principally to find the pounds of water evaporated per pound of coal, and to get the boiler horsepower output of the two boilers tested. Needless to state, a test of this kind is very necessary from time to time for an accurate knowledge of the efficiency of boilers, which may be impaired by many causes that, if not detected, may mean quite a loss. To facilitate matters, we had a water meter of the turbine type, which we first tested for

accuracy. This was done in the following way:

We passed the feed water, before it was heated by exhaust steam, through the meter to a barrel, where it was weighed. Knowing from the meter reading the number of cubic feet which passed through it, and actually weighing the water and noting its temperature, we easily found our factor of correction. Thus, in the first case, 3 cubic feet passed. At 62 degrees Fahrenheit, 3 cubic feet of water weighs $3 \times 62.36 = 187.8$ pounds. Our reading on the scales was 244 pounds, of which the barrel weighed 73 pounds, so the actual weight of the water was 171 pounds. The constant we must use in the first case is, therefore,

$$\frac{171}{187.08} = 0.914.$$

Having found the constant for a number of cases and taking the average, our meter is now accurate enough for our work. Reference to the accompanying table will show the average constant to be 0.97.

In a test of this nature one must be careful to get exactly the same conditions on closing the test as on starting. Therefore, the hight of the water in the boilers was carefully marked by tying a string round the water-gage glass; also the cleaning of the fires was such as to produce like conditions on starting and closing the test.

Coal was first shoveled into a barrel and weighed before thrown into the fire. Some of the readings taken were not absolutely necessary. Observations were made every ten minutes.

The number of cubic feet read on the meter was 1216×60.34, or the number of pounds per cubic foot at a temperature of 189 degrees equals the number of pounds equivalent to the meter's reading. This must be corrected by the constant 0.97, for the reading is too large.

This must also be corrected for the evaporation factor which is the ratio that the total heat H in one pound of steam at the given pressure and reckoned from the temperature t, of the feed water, bears to the latent heat of evaporation at 212 degrees, or l.

That is,

$$e = \frac{H - (t - 32)}{l}.$$

The reason that we must introduce this factor is that if the water were supplied at 212 degrees instead of 189 degrees the boiler would evaporate more water, and also because our boiler horsepower is the evaporation of 34½ pounds of water from and at 212 degrees. We must, therefore, change the present reading to an equivalent of from and at 212 degrees. This can easily be done by taking the total of one pound of steam at the given pressure, and subtract from this the feed-water temperature, minus 32, because steam tables are figured on heating water at 32 degrees Fahrenheit. This gives us the actual number of B.t.u. one pound of water has received. Dividing this by the number of B.t.u. needed to convert one pound of water into steam from and at 212 degrees Fahrenheit, we get a result which shows us that had the water been supplied at 212 degrees instead of 189 degrees we would have had heat enough to change 1.06 pounds of water into steam instead of only one pound as before.

We then have the equivalent of water evaporated from and at 212 degrees by taking the meter reading, multiplying it by 0.97, the meter constant, and the result by 1.06, the factor of evaporation. Thus we obtain

$$73{,}373 \times 0.97 \times 1.06 = 75{,}442 \text{ pounds}$$

of water that would have been evaporated from and at 212 degrees Fahrenheit if our feed water had been supplied at that temperature.

As we burned 9235 pounds of coal and evaporated 75,442 pounds of water from and at 212 degrees we get $75{,}442 \div 9235 = 8.17$ pounds of water evaporated per pound of coal.

As the test lasted 7.5 hours, we evaporated $75{,}442 \div 7.5 = 10{,}059$ pounds water per hour from and at 212 degrees Fahrenheit.

As 34.5 pounds of water evaporated per hour equals one boiler horsepower, $10{,}059 \div 34.5 = 291.6$ boiler horsepower developed per hour. The table gives the result of our test.

JUSTIN SCHWARZ.

New York City.

BOILER TEST.

Time.	Meter. Reading.	Meter. Used Cu.Ft.	Coal. Boiler No. 1.	Coal. Boiler No. 2.	F.W.T.	St. Pres.	Total Amps.	Volts.	Notes.
			Lbs.	Lbs.					
9.15	228		500	500	190°		450	244	Fire Boiler No. 1.
0.45	308	80	500		190°	87.5	540	240	Cleaned at 8:15.
10.15	413	105		700	186°	82.5	460	240	Fire Cleaned.
0.45	492	79	500	500	186°	87.5	450	238	Boiler No. 2.
11.15	535	43			189°	95	440	241	
0.45	629	94	500	500	189°	92.5	440	241	No. 1. Top of Breech. Flue Tem. 512° at 400° F.
12.15	704	75			188°	98	230	247	No. 2 as above only.
0.45	784	80		500	190°	87	390	245	Fire Cleaned. No. 1 Ashes = 380 Lbs.
1.15	856	72	500	500	190°	88	440	245	Draft No. 2 = .5"
0.45	938	82			190°	84	450	248	Draft No. 1 = .6" as above.
2.15	1004	66	500	500	190°	93	485	245	N.B. Draft same.
0.45	1094	90		500	190°	92.5	450	246	with Steam Blowers On or Off.
3.15	1174	80	500		189°	97	375	248	Ashes 700 Lbs.
0.45	1260	86		765	190°	70	425	245	FireCleaned, No. 2 at 4:15.
4.15	1341	81	320	450	190°	85	420	245	Fire Cleaned No.
0.45	1444	103			188°	90	440	240	1,350 Lbs. Ashes.
	Total Cu.Ft. 1216		Total. 9235 Lbs.		Av. 189	Av. 88.6	Av. 430	Av. 243.5	

METER TEST.

Cu.Ft.	Temp. H 0	Weight Cu.Ft. at Temp.	Meter Read in Lbs.	Total Weight Incl. Tare.	Tare.	Net Weight Weig'ed	Const'nt
3	62	62.36	187.08	244	73	171	0.914
3	62	62.36	187.08	248	72	176	0.942
3.	63	62.36	187.08	254	73	181	0.969
2	64	62.35	124.72	221	103	118	0.947
2	63	62.36	124.72	227	101	126	1.01
2	62	62.36	124.72	222	102	120	0.966
2	62	62.36	124.72	232	105	127	1.019
							0.97 Average

Coal used. Day fair and clear. Total ashes = 1430 pounds. $1216 \times 60.34 = 73{,}373$ lbs. water. Evap. factor = 1.06. Water meter correction 0.97. ∴ We have 75,442 lbs. from and at 212° F. $\frac{75{,}442}{9{,}235} = 8.17$ lbs. water per lb. coal burned. $\frac{75{,}442}{7.5} = 10{,}059$ lbs. water evaporated per hour. $\frac{10{,}059}{34.5} = 291.6$ B. Horsepower. Elec. hours $= \frac{430 \text{ amps.} \times 243.5 \text{ volts}}{746} = 140$. Elevator wattmeter: At 4:45 p.m. = 95.118, at 9:15 a.m. = 95,050; difference = 68 kw. 40′ of ¾" hose used from meter to barrel.

The Curtis Horizontal Steam Turbine

A Purely Practical Article Giving Plain Directions for Operating a Type of Machine about Which Little, if Anything, Has Been Published

BY H. E. TWOMBLY

Following the advent of the Curtis steam turbine, there have appeared a number of articles relating to its construction, erection and operation. It is noticeable, however, that nearly all of these papers treat of the vertical-shaft turbine, while very little has been written in a practical vein concerning horizontal units of, perhaps, from 200 to 500 kilowatts capacity.

The foundation should be substantial, particularly if the unit is a long one. If the set has three bearings the following construction may save considerable time, trouble and money which otherwise might be spent in ferreting out balance troubles: Take about six heavy rails a little longer than the machine is wide, and have the top surface of each machined true. Then level these very carefully on the masonry foundation and bed them in cement. They cannot be leveled too carefully. When the cement has taken a good set, the machine may be placed in position on these rails and bolted down.

With the machine in place, with all fittings, piping, etc., complete, the first thing to be done is to unbolt and remove the plate that covers the oil cistern in the base at the generator end. Make a careful inspection to see that no dirt is present. Lift the wire-gauze strainer from the pump and look for dirt. If you wish to clean the oil cellar, remove the small plate that is on a level with the floor of the cistern and turn a hose into the upper opening, after which wipe the interior dry. Now fill with a good-quality engine oil until the pump casing is covered two or three inches. As soon as the cistern is filled, replace the cover and screw it down.

Disconnect the horizontal floating lever of the pilot valve from the vertical rod at *a*, Fig. 1, and work the valve stem *v* up and down. Make sure that it will not stick, and then re-connect the lever. It is very important to see that all cotter pins on this rigging are properly spread.

The governor arm is pivoted on two steel points at the top of a forked support. These should be screwed up just the right amount, so that the arm will work freely on its pivots, but will not be too loose. Then set up the lock nuts.

Also inspect the emergency throttle valve and tripping rigging. Set it and see that it trips properly when you pull out the tripping lever by hand. When the emergency is set, the lever should be ⅛ inch from the emergency ring. If the ring runs eccentrically, this measurement should be taken with the ring turned so that the distance between it and the tripping lever is a minimum.

If you have to inspect the generator yourself, see that it is wired according to the print furnished by the manufacturer and see that all connections are tight. Brushes should be fitted accurately with sandpaper and the rocker arm set by the mark on the yoke. See that the flexible-copper connections to the brushes do not touch any moving part of the commutator or armature.

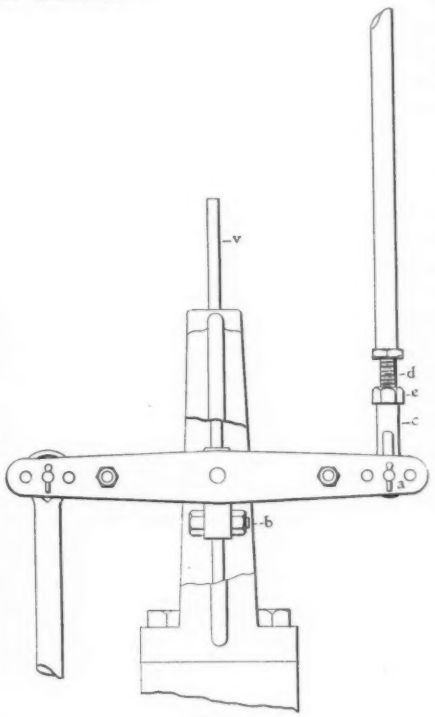


FIG. 1

Lubrication

Previous to starting pour a liberal amount of oil into each bearing, removing the cap if necessary. Also pour a considerable quantity through a funnel into the thrust bearing.

Now oil the turbine preparatory to starting; oil the gimball bearing on top of the governor, the governor rigging, cam-shaft bearings and valve-stem guides. Give the sight oil feeder, on top of the thrust bearing, one complete turn open and open the bearing-oil baffler about three turns. The baffler is a sort of reducing valve that is used to reduce the pressure of the oil before it enters the piping leading to the bearings. See that all proper cocks and valves in the oiling system are open, including those on the gages.

Open the exhaust valve and turbine drips and start the condenser pumps. After turning steam on the carbon-ring packing, the vacuum should rise to its normal value. If it does not, close the exhaust and see if anything is wrong with the condenser. If that is all right, screw a pressure gage into the turbine and with the exhaust closed, admit steam until the gage registers about 5 pounds. This will force water out of the leaks and thereby indicate them. They can be stopped by peening the iron next to them or by painting with asphaltum paint. If the lagging is already on, it might be well to remove it before making this test.

After the vacuum is secured, turn on the bearing-cooling water and with the steam drips open, admit a small amount of steam to warm up the turbine. In about five minutes the drips may be closed and the turbine turned over slowly. Sometimes turbines will not start with a considerable steam pressure acting on them. This is due to the wheels being hard against the intermediate or redirecting blades. Should this condition be encountered, leave the steam turned on and adjust the screw in the end of the thrust bearing, which will move the wheels clear and allow them to turn. The thrust screw turns considerably harder when the wheels are stationary than when they are running.

As soon as the machine starts there are several things that may claim immediate attention. The wheels may rub against the intermediates. This produces a shrill squeaking or a grinding noise if the machine is running slowly, but when running at full speed it sounds more like a pneumatic riveter on a small scale. Adjust the wheels at once and tighten the lock nut on the adjusting screw. Now look to the oil supply immediately. See if the gage on the pump registers. If it does not it may be out of order, so unscrew it and see if there is pressure in the pipe. Should there be none, shut down at once and examine the pump. There may be oil in the pipe, but not under pressure. This could be caused by the oil returning to the oil cellar through an improperly adjusted relief valve, which should be set up at once, if such is the case. Supposing there is pressure from the pump, however, next look to see if

the gage on the bearing registers. Be perfectly sure that oil is flowing through the bearings. Some machines have a manifold in the drain pipes so that this point can be ascertained. If you are not positive about it and there is no other way of telling, unscrew the piping somewhere. When these points have been taken care of, bring the speed to about 200 or 300 revolutions per minute, when there should be sufficient oil pressure to operate the steam valves.

The Governing Mechanism

Let us digress a moment to study the action of the governing mechanism with the help of the diagram, Fig. 2. When the machine comes up to speed, the governor *g* pulls down on the gimball bearing *h*, which raises the end of the governor rod at *i*. This operates the pilot valve *j* and admits oil to the "hydraulic" *k*, which in turn forces the rods *l l* in the direction shown, thereby operating the cam shaft *m* and closing the steam valves.

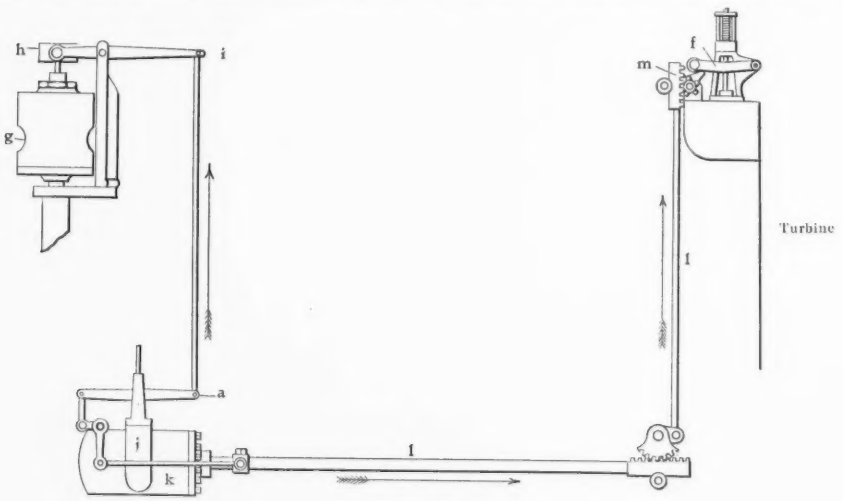


FIG. 2

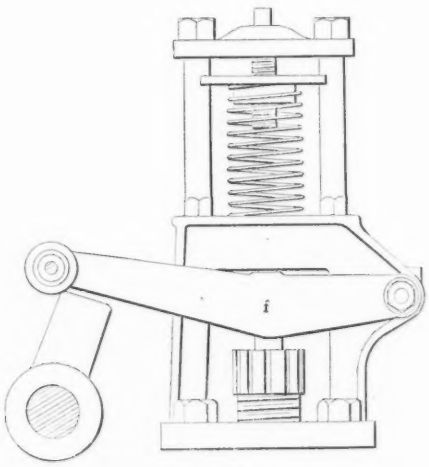


FIG. 3

With these principles in mind we may continue more intelligently.

Disconnect the governor rigging at *a*, Fig. 1, and by moving the pilot valve up and down by hand, operate the entire set of steam valves to make sure that none of them sticks and remains open. If a valve should stick the governor would not close it and the machine might speed up. Now put the rigging together again and inspect the cam positions. The first cam should occupy a position with respect to its roller as shown in Fig. 3. That is, the cam should be just on the point of closing the first valve. Pull up on the lever at *a*, Fig. 1, which has a small amount of lost motion. If properly set, this slight raising of the pilot-valve stem will start the cam shaft and allow the first lever *f* to drop a little. If you do not get this effect, loosen the clamping bolts at *b*, Fig. 1, and move the valve stem to a position so that you do get it. The stem may be secured in this new position by tightening up the bolts again. If a finer adjustment is needed, it may be secured by disconnecting at *a* and screwing the part *c* in either direction on the threaded rod *d*, securing it finally with the lock nut *e*.

Providing no leaks have appeared in the steam, oil or water connections, the set is now ready to be brought up to normal speed, which is usually in the vicinity of 1500 to 1700 revolutions per minute. Give the turbine more steam. When it reaches normal speed and the valves all close but the last one, lift up on the end of the governor arm at once to see if the governor will shut the last valve. If it will not, cut the steam off and adjust the pilot valve so that it will, even if you have to sacrifice the opening of the first valve to some extent.

After the machine is running at full speed, open the emergency throttle valve wide and then turn it back about one-half turn to prevent its sticking in case the emergency should trip. The oil pressure should now be adjusted. Set the relief valve so that the pressure at the pump is about 80 pounds and turn the baffler until the bearing gage shows 10 to 12 pounds. Running with no load on the turbine, turn the clearance-adjusting screw on the thrust bearing counter-clockwise, thereby letting the wheels back until they rub slightly; then note the number of turns in a clockwise direction that are necessary to pull the wheels forward until there is a slight rubbing. Now let the wheels back not quite to the central point—that is, leave them pulled forward a little. This will compensate for any slight dishing of the wheels by the steam when full load is thrown on. The set may now be loaded and after about an hour's run with load, the drains from the first stages should be closed, leaving only the drain from the exhaust open. Continuous operating conditions are now established and the turbine will probably run better the longer it runs.

Some Points on Operation

Any device or mechanism which remains inactive for any length of time, or which does not have a regular routine duty to perform, is likely to be neglected by the operator. A case in point is the tripping mechanism of the emergency throttle valve. The writer ventures to say that in a large number of cases this device receives little or no attention, and the engineer does not *know* whether it will work properly; yet there is no device connected with the turbine on which so much depends. It is probably the only thing that will save the turbine if it starts to speed up, and the attendant is not near. So it is absolutely essential that this device shall be kept in perfect condition. Trip it out by hand often and oil it when necessary. If it sticks or shows any unevenness of action, find out what is wrong and fix it. At intervals of about two weeks the set should be run up until the emergency trips. This can be done by disconnecting the governor rigging at *a*, Fig. 1, so the steam valves will not shut when the speed reaches normal. Gradually bring the machine up to speed, keeping very careful watch of the tachometer. Do not allow the speed to exceed 112 or 113 per cent.; the emergency is supposed to trip at 110 per cent. of normal speed. If it does not, it can be adjusted by varying the tension on the spring contained in the emergency ring which is mounted on the shaft. If the spring is tightened, the value of the speed, at which the ring throws to an eccentric position, is raised, and if the spring is loosened, the tripping point is lowered.

Keep a close watch on the governor rigging and check any tendency to work loose or come apart. Do not forget to oil the rigging; if it becomes dry and gummy, enough friction may be introduced to cause hunting. Do not allow the steam-valve guides to become dry or sticky. A small quantity of oil should occasionally be drawn from the bottom of the oil cellar and examined for impurities. Samples should be taken after the machine has been standing several hours and the oil has settled.

Inspect all bolts periodically and when

necessary tighten them. It is a fact that a slight tremor may in time cause bolts or screws to loosen.

If the carbon seal should for any reason become leaky, remove the containing case and take out the rings. These are composed of blocks of carbon held together by a spring band. A closer fit may be obtained by filing or sandpapering the ends of the blocks so as to shorten them a trifle. Try the fit occasionally while reducing the blocks by assembling the ring on the shaft. If any high spots are noticed on the bearing surface, reduce them with a scraper. When properly fitted there should be a clearance between ring and shaft of approximately one-half of one-thousandth of an inch for each inch of shaft diameter. When ready for the final assembly, coat the bearing surface of the carbon with a thin layer of cylinder oil, which will help to fill up the hollows and scratches. Fitting and surfacing the rings is a particular job, one that requires careful workmanship.

There is seldom any need to adjust the speed of the machine, because the governor is set at the factory. If desired, however, the speed may be raised by tightening the main spring against which the flyballs of the governor act. The spring may be tightened by turning the large hexagonal nut *n*, Fig. 2, on top of the governor in a clockwise direction. After turning this nut in either direction always turn it a little the other way. This is to prevent the mechanism from being twisted and binding in its guideways which might introduce a lag into the governor action.

Balance

A good running balance is established on each unit before it leaves the factory, and the balance should be satisfactory when the installation is complete on the customer's premises. If for any reason it is not, rebalancing may be effected by screwing weights into the turbine wheels. Access to the wheels may be had by unscrewing the cap on the short section of pipe which protrudes from the inlet or front end of the turbine. Provision is also made for fastening balance weights in the rotor of the generators.

If the balance is good at one time and becomes bad at another, it is safe to say that the conditions under which the machine is running have changed. Perhaps one or two instances of this sort would prove suggestive. In one instance there was a two-stage turbine which had been in satisfactory operation for some months. Upon starting up one morning, the balance became poor and kept growing worse until the whole machine was vibrating very badly. Investigation revealed that the drain from the first stage had been left closed over night and had not been opened at all that morning. Therefore there was considerable water in the wheel casing. The drain was opened and in five minutes the machine was running as quietly as ever.

At another time a vibration was set up quite unaccountably. The turbine was gone over carefully and everything seemed to be in proper condition. After speculating for some time on the cause of the trouble, it was found that on starting a rather small amount of steam had been turned on the carbon packing and for some reason—probably the heating and consequent expanding of the valve—the steam had become nearly all shut off. This left the shaft running against dry carbon rings which finally set up a vibration. In a few minutes after turning on the packing steam the set was running properly.

There was one unit which consisted of a turbine driving two 125-volt direct-current generators. This machine had a peculiar way of running alternately well and badly. Sometimes the balance would be very poor all day and the next day the operation might be first class. Finally it was discovered that the balance would begin to improve and become very good about a half hour after thoroughly lubricating the commutators. This led to an inspection of the brushes, some of which were found to be stuck tight in their holders. The brushes were all carefully looked over, cleaned and made to work freely in the boxes of their holders. When the set was started again it ran perfectly.

Saturday evening, October 24, the members of Troy Association No. 6, N. A. S. E., of Fall River, Mass., listened to an illustrated lecture on "Condensers and Condensing Pumps," by F. L. Johnson, associate editor of Power and The Engineer.

Flywheel Accident at Mattoon, Ill.

By Ethan Viall

On Monday morning, October 12, the big flywheel at the Illinois Central Railroad shops, Mattoon, Ill., burst and tore great holes in both sides of the engine room and also knocked off most of the roof, but otherwise did little damage, the engine itself being practically as good as ever and only a few broken steam pipes resulted. The flywheel was 14 feet 1 inch in diameter, weighed about three tons and was traveling at the rate of 76 revolutions per minute.

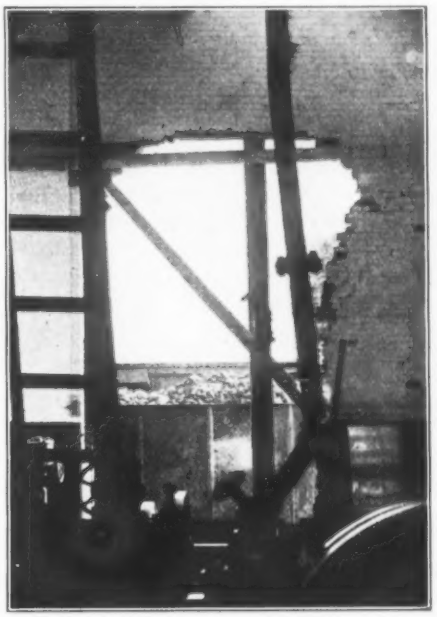


FIG. 2. ONE OF THE HOLES IN THE ENGINE-ROOM WALL

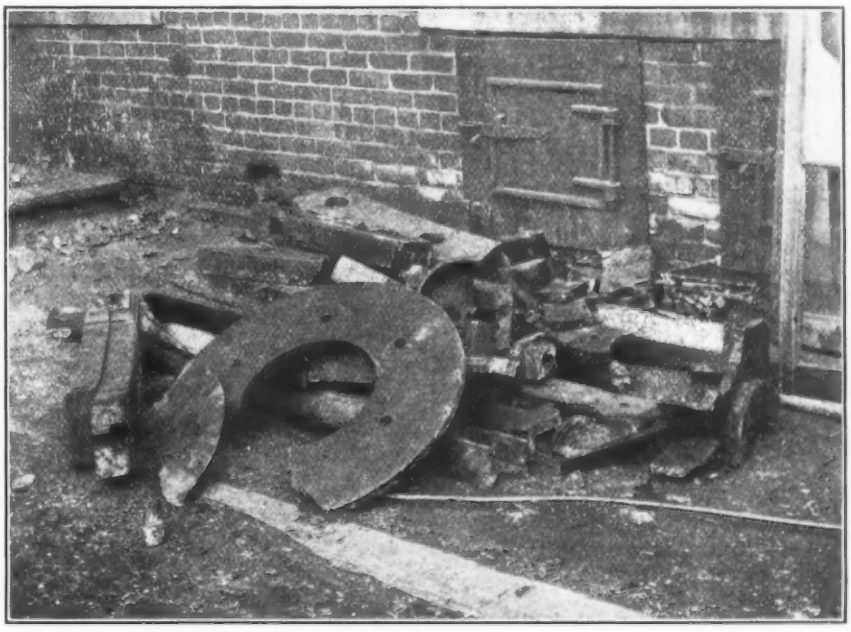


FIG. 1. A COLLECTION OF THE BROKEN PARTS OF THE FLYWHEEL

The exact cause of the accident is not known, though the failure of the governor

belt is the general opinion among those in a position to hazard a guess. The flywheel was reduced to a mass of scrap iron of rather small pieces, as shown in Fig. 1. All of the parts that could be found are in this pile. The largest piece, weighing about 250 pounds, was thrown a distance of about 200 yards.

Fig. 2 shows the hole torn in the side of the engine room next to the railroad track. A car standing on the track at the time the accident occurred was nearly cut in two. The coal car standing across the hole when the picture was taken gives an idea of the size of the hole in the wall, part of which was originally a window.

It was expected to have the engine running again by the following Saturday, and from the excellent condition of the engine it was entirely possible, providing the new flywheel was received in time.

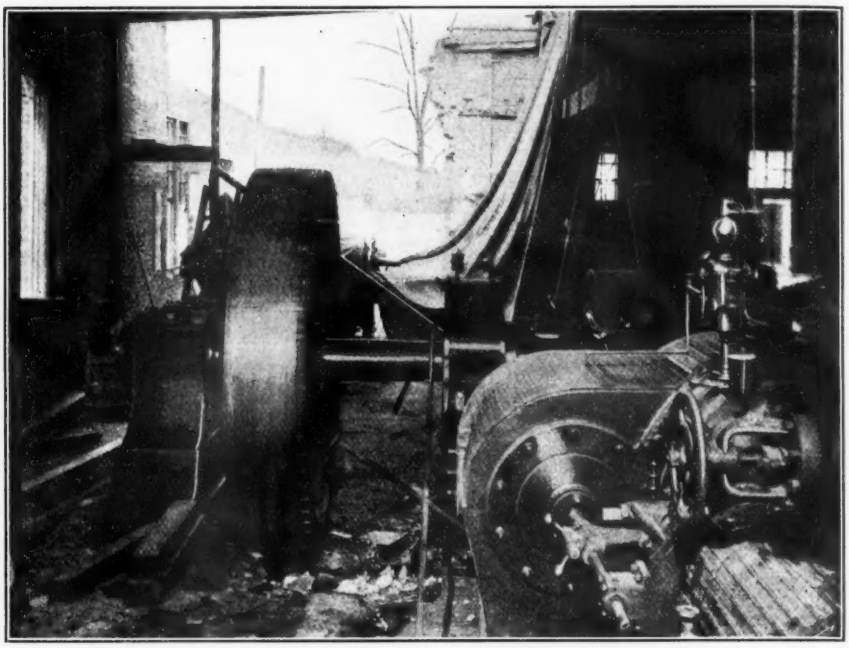


FIG. 1. ONE-HALF OF DOUBLE FLYWHEEL STILL IN PLACE

Keokuk Electric Light Plant Wrecked by Flywheel

Another flywheel wreck, and a bad one, occurred October 19 in the electric-light plant of the Keokuk Electric Railway and Power Company, at Keokuk, Iowa. The accident happened during the night shift, at about 8 o'clock in the evening, killing the night engineer and partially wrecking the building. A large gap about 20 feet in length and 10 or 12 feet wide was rent in the brick wall on the south side of the station, while at the north end there was another hole of still greater dimensions. In the roof, upon which there were 6 inches of cement, two large circular holes were created by the fragments in their upward passage from the wheel.

From the number of these holes it would appear that at least four pieces of the wheel made their exit from the structure. Portions of the brick walls were carried a considerable distance from the building, but the interior damage was confined to the engine room, in the north portion of which there was a mass of confused wreckage. Three dynamos were rendered temporarily useless, and the engine to which the wheel was attached was more or less damaged. The entire northwest corner of the building will have to be rebuilt. As it appears, two flywheels were mounted side by side on the shaft, each having a 14-inch face and 10 feet in diameter. The one was wrecked and the other apparently uninjured. The wheel, as reported by the manager of the plant, was purchased new three years ago and was of solid construction for the speed, which was only 173 revolutions per minute.

FIG. 2. ONE OF THE LARGE OPENINGS MADE IN WALL OF ENGINE ROOM

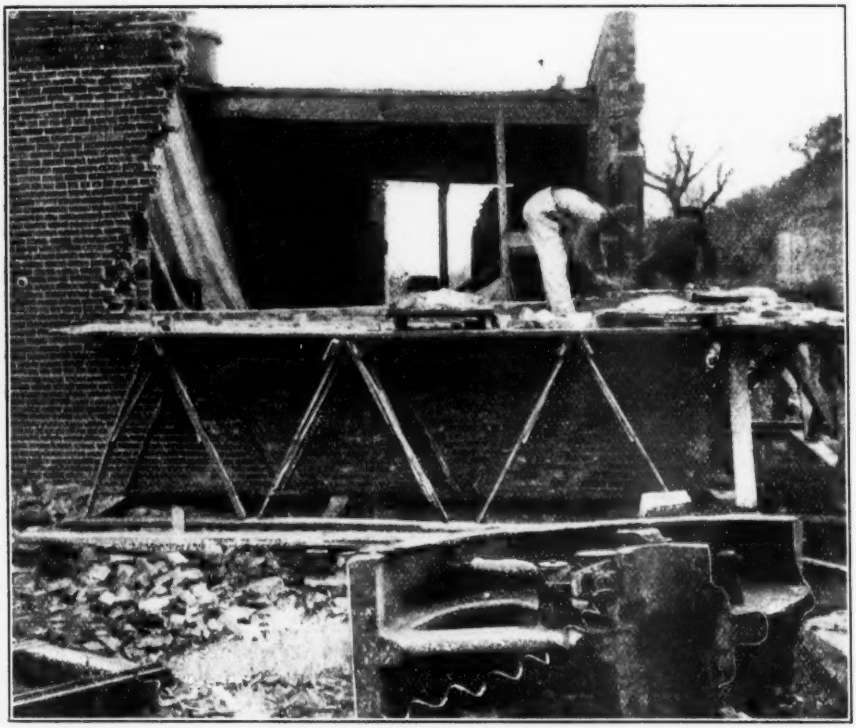


FIG. 3. REBUILDING ENTIRE NORTHWEST CORNER OF BUILDING

At the time of the accident there were only four employees in the building, the engineer who lost his life, the oiler, a fireman and a coal passer. All escaped uninjured but the engineer, whose dead body was found lying near the south wall, almost denuded by the force of the explosion. One of the legs of his overalls remained, while the other hung over the brick wall in one of the gaps that had been created by the flying pieces.

A peculiar feature of the disaster was the wreck of a frame house about 400 feet away. Half of the building was badly damaged as the result of the entrance of a huge piece of the wheel,

weighing between two and three thousand pounds; it was 4 feet in length, about 3 feet in width and 6 or 7 inches in thickness. This mass of iron entered the side of the house, struck a bed, which it demolished, and fell to the floor within a few feet of the six occupants, all of whom miraculously escaped. A short distance away another mass of iron fully as large fell and plowed its way along the ground.

There were two generating units in the plant besides the one put out of action, and these machines were run in parallel with the damaged generator to carry the load, which consisted of incandescent lamps, power for motors and a street-railway load. The switchboard was demolished, so that although two of the generating units were uninjured, it was impossible to furnish current for some time.

As an explanation of the accident, it is suggested that the engineer might have started to shut off the engine before throwing out the switch connecting the wrecked unit in parallel with the other two, thus converting the generator into a motor and greatly accelerating the speed. Possibly this may have been the final cause of the disaster, although no conjecture has been made as to what caused the engine to speed up in the first place.

Keeping Oil and Scale out of Boilers

By William Westerfield

That oil in boilers is a very undesirable thing, all agree, and it would seem from matter occasionally appearing in the technical press that it is, in some cases, a difficult thing to avoid. On the contrary, however, I regard it as very simple.

Oil usually gets into the boilers in simple noncondensing plants through the open feed-water heater. Most of these heaters are equipped with oil traps which, if properly cared for, will dispose of the oil which enters the heater with the exhaust steam and prevent its being delivered to the boiler in the feed water. Even if the heater has no automatic separating device, the oil may be kept from entering the boilers if the water in the heater is kept up to the proper hight at all times, as the suction is at the bottom of the heater and the oil, floating on top of the water, cannot get into the boiler as long as this condition exists. At intervals the heater should be blown off through an opening that may be provided for the purpose, and the oil that has accumulated may be got rid of in this manner.

With the closed type of heater, there is no reason why there should be any trouble with oil in the boilers. The closed heater is not, however, as efficient as the open type from the fact that in the open type the steam and water come in direct contact, while in the closed heater they do not.

In condensing plants the oil is exhausted with the steam from the engines to the condenser, is delivered by the air pump to the hot well, and from there it goes to the boilers. I have had considerable experience with compound-condensing plants, and have taken charge of some where the boilers were in very bad condition on account of oil in them. I have in each case removed the oil that had accumulated, and also prevented more from going into the boilers, by means that are within the reach of every engineer who cares to go to a little trouble.

My practice is to boil out the boiler with caustic soda, and then thoroughly wash it out. If once is not enough, and it usually is, I repeat the process. I do not advise the use of caustic soda in any other way than as above, and would not advise anyone to use it unless the case demands it, and then the boiler should be very thoroughly washed out before putting in service again.

I have my hot well divided into four good-sized compartments, with each dividing wall containing openings in the bottom for the water to pass through to the next compartment. The air pump discharges into the first compartment, which is partly filled with excelsior or some similar material. The water passes to the second compartment through openings in the bottom of the wall dividing the first from the second compartment, thus leaving most of the oil on the surface of the water in the first compartment, and so on to each succeeding compartment. There are openings which can be used as skimmers for each compartment for drawing off the accumulated oil. I also use a float-regulating valve at the hot well to maintain the water level so that the last compartment, from which the boiler feed is taken, will never get low enough to allow oil to be taken into the pump suction.

In dealing with common scale I use common kerosene, which all agree is harmless to boiler plate. When using it one must expect to have trouble with gaskets, if they are the antiquated article cut from 30-cent sheet packing, and the opposition to the use of kerosene arises mainly from this. I always have all gaskets made of asbestos sheet packing or similar material. For the larger sizes it is advisable to use the molded asbestos gaskets, as there is no waste in cutting them out.

FIG. 4. WHAT HAPPENED TO A FRAME HOUSE 400 FEET DISTANT

Power Plant Design

On Tuesday evening, October 27, George A. Orrok, of the New York Edison Company, talked to the Modern Science Club of Brooklyn upon the above subject. It has been truly said that life is made up of compensations. It is equally true that power-plant design is a series of compromises. A designer starting out to produce a station according to his very best ideals will encounter conditions due to geographical position, to the exigencies of available sites, the necessity of submitting to the personal preferences of his client or employer, of using machinery or material already in hand or which must be purchased from parties with whom his client is in relation, and last, but not least, the restrictions imposed by financial considerations. All must be met and compromised with, with the result that the station when completed is far from the ideal which existed in the mind of the designer when it was proposed.

Two Stations

The speaker described two stations with the design of which he had been connected; one upon a river bank so precipitous that the roof of the boiler house could be located at the level of the street and the coal received at that point, and worked continuously downward until the ashes were dumped into the river and were taken out by the current at the lower level. Water from the canal came to the plant under sufficient head to serve the condensers and allow of a barometric-tube discharge, dispensing with all auxiliary machinery so far as the condensing plant was concerned.

Another plant of about half the capacity was located in a meadow, standing upon mud from 80 to 100 feet in depth. This was placed upon a floating concrete foundation, supported by piles sufficiently to keep it in position, and has settled ¾ inch in five years.

Next to a solid rock foundation he preferred piling and concrete. Three tons per square foot is a good allowable load for earth foundation.

Concrete Conduits for Condensing Water

For condensing-water tunnels he preferred either circular or oval conduits of concrete. When these are of large size they can be best built ashore, floated to place and sunk into position upon a pile foundation. It will save trouble if the discharge end of the outgoing tunnel is submerged. Ten or 12 feet per second used to be an allowable figure for the speed of water, but he preferred to design them for a maximum speed of between 4 and 5 feet per second, and then when the velocity runs up to 7 feet, there is not much loss. It is a fact that there is less loss of head by increase of speed in a smaller cast-iron pipe than in a large concrete pipe.

He advised his hearers, when they had any voice in the matter, never to consent to building without a steel frame. With this construction it can be told where the strains are going to land. The building department of New York is too liberal in its allowance upon this kind of work; 16,000 pounds fiber stress in an iron beam is too much for power-house work. A not uncommon experience is to be told to design a neat, plain station, and as the work progresses to see a desire for ornamentation, terra cotta, tile work, etc., manifested, which will add materially to the cost and set but illy upon the original conception.

Handling Coal and Ash

Not many years ago, a coal merchant had bragged that he was unloading coal from a steamer at the wharf at a cost of 14 cents per ton. This was for a steamer holding 3000 or 4000 tons of soft coal. It is nothing today to unload a barge containing 1000 tons for 1½ cents per ton, and the same man is today unloading his steamers at a little over 1 cent per ton. The best practice is to use a steam-driven tower with a 1-, 1½- or 2-ton shovel, making the hoist in the bucket itself. In other words, carry the coal up to the highest point while you have hold of it. The best way to distribute it when you have it up there is in cars operated by an endless rope. Bucket conveyers are advisable in certain places, and the belt conveyer is extremely handy. He had never seen an electric hoist that would work fast enough.

For handling ashes the ideal system must be a closed one, and he thought the new pnuematic system, wherein a vacuum is produced in the receiver and the ashes sucked into it, promised a pleasing solution of the question. Conveyers are a source of trouble and cars are a nuisance.

A Choice of Prime Mover

In discussing prime movers, Mr. Orrok said that there are in this country 20 large gas-driven stations, about 50 turbine stations, and goodness knows how many reciprocating-engine stations. They are all good within their load limits. In determining the type of prime mover the load factor has an important effect. For a load factor of anything above 30 per cent. the gas engine comes into consideration, and when the load factor is very high the gas engine gains a considerable advantage. The turbine must have condensing water and plenty of it. A combination of reciprocating engine and turbine is good, if you have a poor engine to start with. For a new station, an all-turbine installation is superior.

So far as steam efficiency is concerned, there is nothing to choose between a reciprocating engine properly proportioned and run and a turbine. A difference of perhaps a dozen B.t.u. per kilowatt-minute. The best recorded results from the steam turbine are those from a turbine built by the Actien Gesellschaft, of Berlin—274 B.t.u. per kilowatt-minute. In America the Westinghouse turbine has made a kilowatt-minute on 278 B.t.u. and the Curtis has come within 1 B.t.u. of the same figure. The best engine results, so far as we know, are about 290 B.t.u. Information is not yet available as to what results were obtained with the engines at the Redondo station, but they must have come pretty near the turbine record to have produced the over-all result which has been published. Inasmuch as it is practically impossible to conduct these tests within 3 per cent. of accuracy, it is evident that there is very little to choose between these types of motor.

With the gas engine it is possible to reduce this consumption per kilowatt-minute in heat units very considerably, especially with blast-furnace gas. The tendency is to use coke-oven gas for the engines, and to use the blast-furnace gas for the stoves. The blast-furnace gas has a heat content of something like 80 B.t.u., while the coke-oven gas has 600 and over. The turbine which made the record run at Berlin consisted of a Curtis section for the high-pressure end and a Zolly for the low. Small steam turbines are coming into extended use and can be run on 30 pounds of steam per hour per horsepower noncondensing, if they are run at the speed for which they are designed.

Boilers

He used Babcock & Wilcox boilers because he could get the required amount of horsepower in the space to which he was restricted, and the boilers would stand the required amount of overload. Any boiler will do fairly well if it is intelligently designed and properly run. Any boiler ought not to be expected to give less than 15 years of good service, and ought to give 40. He knew of one which has run 28 years and is still in good condition. It is said that an improvement of 7 per cent. is attainable by incasing boiler settings so as to prevent the infiltration of air. While the standard evaporation is 3⅓ pounds per square foot of heating surface, it is not at all unusual to run up to 9, and in the marine service to 13 or 14. The record test with this kind of boiler is 18 pounds.

Flues and Chimneys

These are things which an engineer would like to get rid of. They take room and they take it in a bad place. One pound of coal will make 375 cubic feet of flue gas, and the velocity attainable with ordinary draft is only about 22 feet per second. A standard 500-horsepower boiler would require 30 square feet of uptake per boiler. The most that can be expected by the use of economizers is a gain of 3 to 5 per cent. This is not so much as can be expected by incasing the boilers, according to some authorities. Mr. Orrok does not use economizers, because he prefers to have his heating surface in the shape of boilers, so that it can be used on overloads.

Cast-steel Pipes for Superheated Steam

In considering steam pipes, Mr. Orrok dwelt upon the peculiar effect which superheated steam has upon cast-iron pipes and fittings, and told of cases which had recently come under his observation where fittings were badly bulged and cracked on the exterior surfaces, although the interior surfaces were coated with a smooth, red oxide so hard that he could not penetrate it with a penknife. The fittings had increased considerably in length, and the diameter was fully an inch larger than when the fitting was put to use. He thought that cast steel was the most likely remedy for the trouble; but the cast steel must be good. For superheated steam he preferred cast-steel valves with the seat

cast in. He was not ready to state definitely that a single-wedge valve is the best, but acknowledged his present preference for it.

Centrifugal Pumps for Boiler Feed

In considering feed pumps the speaker discussed the possibilities of the centrifugal pump, of which there are many today in use for boiler-feed purposes. They are extremely simple and their uniform delivery takes away all strains due to shock. If the valve is shut off in the delivery pipe, the pump simply continues to churn the water around without producing the disastrous consequences which would follow upon a similar action with a positively-driven plunger pump. A centrifugal pump treated in that way had raised a considerable racket until they found that the noise was due to the generation of steam by internal friction, and put in a bypass so as to deliver a part of the water around to the suction and keep up a circulation. These pumps have been used for four or five years. There are in a number of stations 1000-gallon pumps which have been running against 700-foot heads for 1½ years with almost no trouble. Such troubles as have been encountered have been simply mechanical and have been cured. Pumps of 300 gallons a minute and over may be turbine-driven. Below that he did not think that turbines would pay. The 1000-gallon pump has an 8-inch discharge.

There is Need of an Improved Jet Condenser

With the surface condenser the principal trouble is with the tubes. Most New York engineers figure on replacing tubes once in three years "whether they need it or not," and they usually need it. The need hereabout is for a jet condenser which will give the same vacuum, occupy the same space, and not cost any more than the surface condenser. The air pump required for such a condenser would be enormous. The air pump for an ordinary condenser will be 30 inches in diameter, 20- or 24-inch stroke, running at 90 revolutions. A jet condenser to maintain the same vacuum should have an air pump five or six times that displacement, and even then might not be able to maintain the vacuum. It has been proposed to use two centrifugal pumps placed on the shaft of a small turbine, one furnishing the water and the other taking it away. A second turbine driving a rotary dry-vacuum pump is also to be applied.

Turbine builders are now rating their units on the load which they will carry continuously for 24 hours with a given temperature rise. Builders of reciprocating and gas engines continue to rate upon the capacity at the point of maximum efficiency, although the tendency is to the maximum capacity rating.

Possible Improvements in Gas Engine Economy

By A. T. Kasley

The great improvement in fuel economy made possible by the introduction of producer-gas engines has stimulated its rivals to such an extent that the gas engine had better look out for its laurels. A recent German steam engine has turned out a horsepower-hour on a trifle over a pound of coal, using superheated steam. The combination of a compound noncondensing steam engine and a low-pressure condensing turbine has also shown some wonderful results.

The gas engine rejects a large amount of heat at temperatures which a steam turbine can make use of; why not combine them? There are two or three firms in this country who are prepared to build turbines suitable for use with steam at a temperature of 150 degrees Fahrenheit, which is about the highest at which it is safe to run the cooling water at the outlets of gas-engine jackets if the cylinder walls are thick. The best construction would be to have a turbine with two or more inlets to receive the steam at the highest pressure it can be produced at in the various parts of the plant. British builders are now ready to build boilers for 150 pounds pressure to be heated by the exhaust gases. Many people are of the opinion that such boilers would not prove lasting on account of the sulphur in the gas, but it has been found that sulphur gases are only injurious when they are moist, so that a boiler containing high-pressure steam would have little to fear, as the high temperature would prevent the steam in the exhaust gases from condensing.

When you come to consider making steam from the jacket water the difficulty immediately presents itself of how to prevent the formation of pockets in the jacket space in which the steam would displace the water and allow a part of the cylinder to become red hot. This trouble can very easily be avoided by placing the turbine on the second floor of the building and running water-circulating pipes up to it. The water in the jackets would then be kept at or above atmospheric pressure by the gravity head so that no steam would be formed in the water until it had risen in the pipe 15 to 25 feet above the engine. It could then be allowed to separate from the water in a chamber and the water returned to the jackets to be again heated up a few degrees.

In the medium-size horizontal double-acting engines, to which this arrangement would probably find its first application, it would be desirable to have two sets of such pipes and chambers so that the water in the piston rods and heads could be maintained at a different temperature from that in the jackets of the rest of the engine. It could very likely be run hotter than the rest of the jacket system.

Placing the turbine on the second floor would also have another advantage in that it would allow the most advantageous application of the barometric condenser; there would not need to be any riser pipe connecting the turbine exhaust and the condenser head. Besides being expensive on account of its large diameter, such a riser has been found to cause a loss in vacuum unless a special pump is installed to remove the water that would otherwise collect in the bend at the bottom.

The effect of such a system on the engine could not but be beneficial. If the water used for the jackets contained lime it could be sprayed into the steam chamber, and the precipitates would not form a hard scale on the interior jacket surfaces, but would collect in the steam chamber and could be periodically removed. There would also be the advantage of having all parts of a casting at or near the same temperature; as it now is, the point where the water enters may be ice cold while another point not far removed may be over 160 degrees. It is little wonder that cast iron under such conditions and perhaps with a layer of scale ¼ inch thick in spots occasionally cracks; rather, the wonder is that cylinders are not more frequently cracked.

It will be seen that besides improving the conditions in the narrow passages of the hollow valve stems, piston rods, and cylinder jackets, it would be possible to use for the bulk of the cooling water required, water that by reason of saltness or acidity could not be used in the jackets, but which could be easily handled by a barometric condenser. The make-up water would only be from one-eighth to one-twelfth of that now used in the jackets, each pound of water not only carrying off the heat units required to raise it to the boiling point, but also that required to evaporate it.

A careful estimate of the saving in power that could be effected by such an arrangement shows that the turbine would be able to turn out one-fifth as much power as the gas engine delivered. If peak loads or a disabled gas engine made it desirable, a gas flame burning beneath the exhaust boiler would double or treble this amount, of course at the expense of the efficiency. The estimate is as follows: For every brake horsepower of gas engine 10,000 B.t.u. would enter it per hour; 3500 would go to the jackets, evaporating 3.2 pounds of water into steam at 4 pounds absolute pressure. At a water rate of 45 pounds this would mean $\frac{3.2}{45} = 0.07$ brake horsepower. But 3000 B.t.u. could be taken from the exhaust gases, giving 2.6 pounds steam at 150 pounds. At a water rate of 15 pounds this would equal $\frac{2.6}{15} = 0.17$ brake horsepower, or 0.24 total. Making a deduction of 0.04 brake horsepower to run pumps, leaves 0.2 brake horsepower, or one-fifth of the engine output.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

Issued Weekly by the

Hill Publishing Company

JOHN A. HILL, Pres. and Treas. ROBERT MCKEAN, Sec'y.

505 Pearl Street, New York.
355 Dearborn Street, Chicago.
6 Bouverie Street, London, E. C.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $4 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 16 Shillings.

Entered as second class matter, April 2, 1908, at the post office at New York, N. Y., under the Act of Congress of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

During 1907 *we printed and circulated* 291,500 *copies of* POWER.

Our circulation for October, 1908, *was (weekly and monthly)* 155,500.

Nov. 3..... 39,000
Nov. 10..... 38,000

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

PAGE

The Practical Operation of Reducing Wheels 769
Capacity of Cylindrical Tanks..... 772
The Theoretical and the Practical..... 772
Flow of Water in Pipes and Flumes..... 775
Some Recent Gas Engine Failures..... 781
Methods of Guarding Against Lightning.... 783
Filtering Oil for Repeated Use..... 785
Setting the Valves of the Westinghouse Three-cylinder Gas Engine..... 786
Possibilities of Low Pressure Turbines..... 787
The Intelligent Use of Boiler Compound.... 788
The Plunger Hydraulic Elevator..... 789
The Quality of Steam..... 792
Practical Letters from Practical Men: Indicator Reducing Motion....Steam Plant Piping Blunders....Making a Water Filter....Lead and Compression ....Explosion of Air Compressing Systems....Faulty Indicator Diagrams ....Engineering Problems....Using Soft Coal Screenings....Low Compression Saves Coal....A Case of Bad Valve Setting....Reinforcement of Lap Joints ....Exhaustion of Ignition Batteries ....Sparkless Commutation....Ability of a Steam Pump Under Stated Pressures....Favors Automatic Devices.... Buying Power and Making It....Waste in a Power Plant....What Would You Do?....Boiler Tests.....793–800
The Curtis Horizontal Steam Turbine..... 801
Flywheel Accident at Mattoon, Ill..... 803
Keokuk Electric Light Plant Wrecked by Flywheel..... 804
Keeping Oil and Scale Out of Boilers..... 805
Power Plant Design..... 805
Possible Improvements in Gas Engine Economy..... 807
Editorials.....808–809

The Steam Dome

The steam dome is the outgrowth of an ostensible demand for additional steam space in return-tubular boilers, when used in connection with steam engines operating at slow speed and taking steam during a portion of the stroke only. This was before the high- or medium-speed engine was designed, the adoption of which modified the demand for a steam dome. Also, the steam dome was originally intended to provide dry steam as well as to form additional steam space. There seems to exist a vague notion, however, as to what should be the relative size of the dome and boiler, and in consequence steam domes are found in many sizes, even for boilers of the same size.

Little can be said in favor of the steam dome. That it produces dry steam does not follow, as the steam contained in the dome is most remote from the furnace, and in many instances the insulating material is entirely wanting, or in such bad shape that the dome is exposed to the cooling influences of draft and surrounding air, which tends to condense the steam and defeat one of the purposes for which the dome was designed. Likewise, the additional steam space afforded by the dome is often counteracted by the introduction of an additional row of tubes.

Another argument against the steam dome is that it is often a source of annoyance. A great many cases can be cited where the steam dome began leaking almost from the beginning of the boiler service, and while calking may remedy the trouble for a short time it generally reappears in the same place, or breaks out in a new place. This trouble is usually caused by poor workmanship in punching the holes in the flanges of the dome and boiler, and in riveting. Furthermore, few things about a steam plant are more annoying than a troublesome steam dome, and if the leak is appreciable and concealed from view it may become a source of danger, due to outside corrosion of the plates and rivets.

The outlet which must necessarily be made in the shell of a boiler equipped with a steam dome cannot but weaken the shell, unless it is properly stayed. This is because the longitudinal sectional area of the shell through the center of a hole cut for the dome cannot be made as strong as if the plates remained intact, even with a strengthening ring.

With low-pressure boilers the steam dome is not so objectionable, but with boilers carrying the pressure now demanded, the steam dome should be eliminated entirely. As a matter of fact, it is well on the way to being abolished, as not fulfilling its intended mission and as a source of danger, besides adding useless expense in construction.

Impracticalities and Their Fruits

In the course of progress there has always been and always will be a certain proportion of what are termed impractical theories. A stronger term is applied to some which are classed as the "ideas of a harebrained inventor." Frequently these theories are so evidently impractical that it is difficult to get the world to take them seriously, and again others are given trials that prove expensive yet are barren of any immediate results. The patent-office reports contain many impractical ideas and theories and there are always a number exploited which do not reach the patent office. Some are so plainly impractical as to lead to speculation as to where, why and how they could be originated and supported. With all this, the fact remains that a goodly number of these theories contain some germ of good; that is, they contain in some form ideas that may be and frequently are later developed into important factors.

There is probably no better example to illustrate this point than the history of the steam engine itself. The early steam engine, as conceived by Newcomen, Savery and others, was in its original conception crude and impractical, but was not so radically different from the modern steam engine that it would be difficult to find similarity between the two or trace the development of the original idea. The early locomotive was intended as a road machine and pushed itself along the road with a number of club-like feet. This was given up as impractical and the railway was invented. Only one hundred years later the road-engine idea has not only been made practical but quite prominent in the automobile, the results being really the fruits of the original idea, which was impractical in its first form and was completely lost for a while in the development of the railroad systems of the country.

So it has been all through the days of progress. It is seldom that the genius who originates an idea develops with it all the details in a practical manner, and it frequently takes years and the work of other minds to get the best results, even when the original idea is evidently both practical and useful. When the theories advanced are more in the form of a dream than a practical proposition, it is more difficult to see the tangible good in some of them, but still many of these dreams contain somewhere in some form or other a germ of good that may be developed and prove of value.

It should not be deduced that every wild theory or idea brought to the attention of manufacturers should be accepted and offers made to work it out on some practical basis. That would not only be impractical, but would involve unnecessary waste of money and time. It does,

however, entitle any man with a real idea or theory, no matter how impractical it might seem, to an audience, and to a fair measure of attention, because frequently, even if the idea outlined is not practical, someone may discover a new lead from it that will be practical. Neither does the failure of an idea, after some effort has been made to put it into practice, brand it as a failure in all parts. The failure may be due to the method of carrying out the idea and somebody else may take the same thing and make a pronounced success of it. In short, some of these impractical theories and harebrained ideas may furnish much of the new thought which keeps the world progressing, and there is a certain measure of respect due them, even though the majority contain only a few grains of real good.

The Electric Motor

Most of our readers are familiar by this time with the stock arguments in favor of electric motors for driving machinery in industrial establishments: cleanliness, absence of long lines of shafting, better power gradation with reference to factory output, etc. There are, however, a few features that are not so generally understood or appreciated, one of these being the inherent property of the motor to indicate changes in the working condition of the machinery which it drives. For example, if the no-load current of a motor direct-connected to a machine of any type has been three amperes right along for weeks or months, and changes to four amperes, it is safe to conclude that the machine it is driving needs investigation. Of course, the increase in no-load current may be due to trouble in the motor itself, but if it is, the trouble will manifest itself in other ways also. When a motor is used for group driving, it serves as an excellent means of indicating the condition of the shafting and bearings. Should the bearings wear or be carelessly adjusted, out of true alinement, the increased friction load will be indicated by a meter in the leads to the motor. In view of this feature, it is a good plan to keep a record of motor intake under all conditions when an installation is first started up and at regular intervals thereafter, whether the motor be used for group or direct driving.

Another valuable feature of the electric motor is its ability to indicate the power requirements of a machine both as to the necessary capacity of the driving motor and as to peculiarities in the torque characteristics of the driven machine. For example, if a trial motor be coupled or geared to a machine which requires fourteen horsepower during one-third of its operating cycle and eight horsepower during the other two-thirds, an indicating wattmeter in the motor circuit will show this, and a simple calculation will suffice to determine that a ten-horsepower motor provided with a suitable flywheel will drive the machine without difficulty.

Another advantage, and one which is indispensable in many instances, is the ability of an electric motor to start up with a heavy load or overload. A steam engine will also do this, but unless it is a compound it will be more than likely to stall on the first dead center; however, the day of steam plants comprising a plurality of small engines is over, and this leaves the electric motor unapproachable in its ability to start up with a heavy handicap.

Composite Power Generation Again

In another part of this issue we publish an article advocating the combination of a gas engine and steam turbine, which has been suggested several times before. The present advocate, however, has views somewhat different from those forming the basis of previous suggestions along this line. He would evaporate some of the cooling water of the gas engine directly by the heat taken out of the cylinder and evaporate more of it in a separate boiler by the heat in the exhaust gases. This would be all right if some way could be devised of concentrating all of the jacket heat upon the small portion of jacket water which Mr. Kasley proposes to evaporate with that heat, but we confess ignorance of any means for so doing. "For every brake horsepower of gas engine [output], ten thousand B.t.u. would enter it per hour," says Mr. Kasley; of this, he figures, "three thousand five hundred would go to the jackets, evaporating three and one-fifth pounds of water into steam at four pounds absolute pressure." Now, there would be circulated about forty pounds of jacket water per brake horsepower-hour; how is the heat to be abstracted from thirty-seven pounds of that water to evaporate the other three pounds? Mr. Kasley is a little obscure, also, as to how he expects to use three thousand B.t.u. from the exhaust gases to evaporate more of the water. The exhaust gases would have to be at an unusually high temperature and contain much more than the usual proportion of the intake heat in order to make this possible.

There is no difficulty about making steam with the heat in the exhaust gases, but the quantity that can be made per brake horsepower of gas-engine output is relatively small. With exhaust gases at one thousand seven hundred degrees absolute and containing four thousand B.t.u. per horsepower, both of which figures are high, only one and one-half pounds of water at two hundred degrees could be evaporated into dry saturated steam of one hundred and fifty pounds gage pressure, using a boiler of eighty-seven per cent. efficiency, which is also an attractive figure as boiler and heater efficiencies go. One and one-half pounds of steam per brake horsepower of gas-engine output seems scarcely worth the plant complication requisite to its production. In a gas plant of a thousand horsepower it would supply a turbine of not more than a hundred brake horsepower and probably only eighty-five.

Work of the Educational Committee

One method of education in steam engineering has been carried to a higher degree of excellence in Massachusetts than elsewhere. The educational committee of the State association of the National Association of Stationary Engineers has for several years furnished a list of lecturers, on subjects pertaining to steam engineering, to the subordinate associations, with the request that each association select as many lectures as possible for the season. As a rule, the expense to the association, for the lecture, has not exceeded the traveling expenses of the lecturer, and in many cases it has been much less.

For the coming winter season the committee has secured the services of forty lecturers, each of whom is qualified to speak from experience upon some branch of steam-engineering practice.

The result of the work of the committee is practically to turn many of the meetings of the associations into "night schools," where engineers may add to their own experimental knowledge the fruit of the experience of others. The engineer takes to lectures as a "duck takes to water," and it is seldom that a lecture to engineers is neglected; and when the hour for questions arrives, the speaker is bombarded so energetically, by queries touching all the phases of his topic, that he leaves the hall feeling that at least *that* evening has not been wasted.

The real engineer is a continuous question mark, and if any statement is made of which he has the least doubt, he does not keep silent, but demands both proof of and reasons why. Massachusetts engineers may well be proud of the State educational committee and the work that is being done by it.

In all turbines the question of vacuum is a very important one, and various improvements have been made in condensers to enable higher vacua to be obtained. The importance of this will be seen when it is remembered that in the average steam turbine 1 inch of vacuum is equivalent to from 4 to 5 per cent. of steam consumption.—Gerald Stoney.

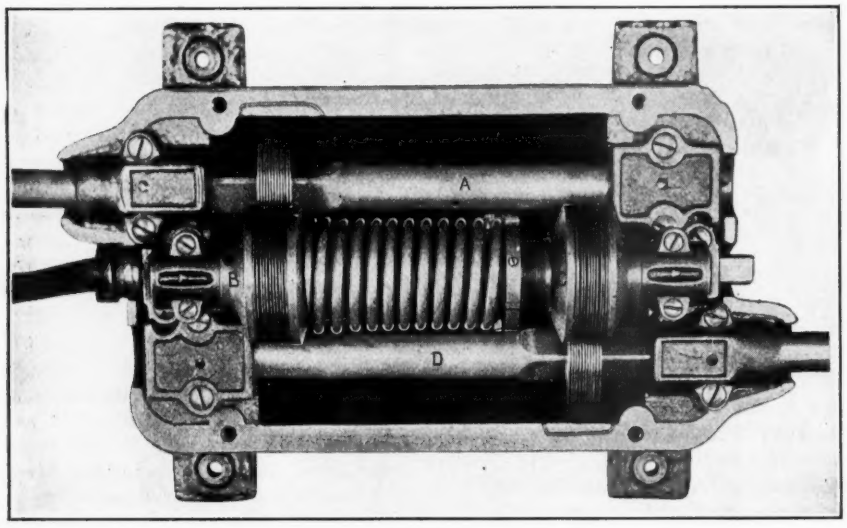
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Dill Variable Speed Drive

As can be seen in Fig. 1 this drive consists of a main or power shaft *A*, carrying a series of thin disks, and intermediate shafts with two sets of disks, *B* and *C*, and a third or transmitting shaft *D*, with a fourth set of disks similar to the first set on *A*. The power shaft *A* runs at a constant speed from any source, and the speed delivered from the shaft *D* depends upon the position of the intermediate shaft with relation to *A* and *D*. This shaft can be moved either toward *A* or *D* by the lever on the outside of the gate, moving it toward *A* decreasing the speed of *D* and *vice versa*. The disks on *A* and *D* are loosely mounted on the squared portion of the shaft so as to be free to move endwise as much as necessary, while the disks *B* and *C*, also loose on the shaft, are forced together by the coil spring in the center, the tension of this being adjustable to prevent slipping and secure the necessary power.



VIEW OF DILL COUNTERSHAFT DEVICE WITH CASING OPEN

One set of the engaging disks has perfectly straight sides, while the other set is slightly tapered, so that there is only a point of contact between the tapered side of the driving disk and the flat side of the driven disk, as in *A* and *D*. As the intermediate shaft is moved toward *A*, the disks at *D* are forced apart to a small extent by the taper of one set of disks, which insure perfect contact, and the variation is taken up by the coil spring. This has the effect of reducing the working diameter of the driving disk *A*, and of also increasing the working diameter of the disk on *D*, so that slower speed results. Throwing the intermediate shaft in the opposite direction increases the speed in a like manner and gives any intermediate speed between maximum and minimum that may be desired.

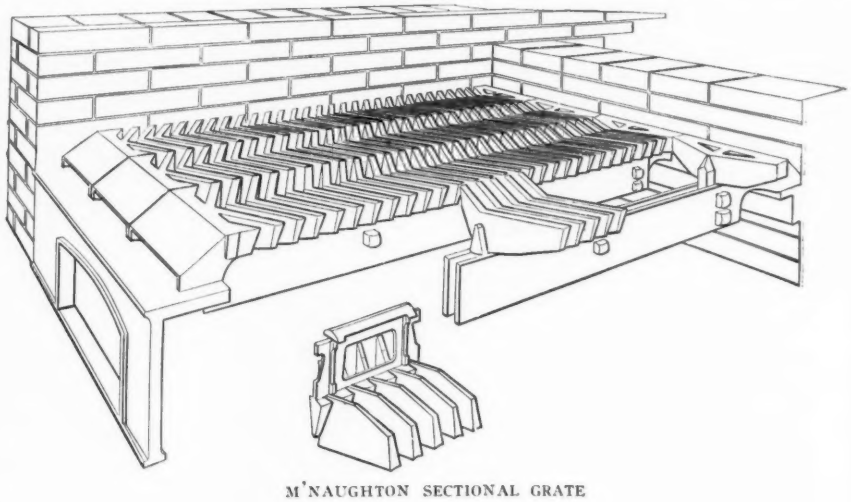
Constant horsepower is obtained in this way, as the tension of the spring varies with the feed, due to the difference in thickness of the tapered disk, and makes the spring stronger when the speed is the slowest. The power transmitted depends entirely upon the number of disks and to 10 horsepower, with speed ratios of their diameter, and they have been built up 30 to 1.

The device can be used either on the floor or on the ceiling in connection with a countershaft. The 5-horsepower drive of this type is 23 inches long, 13 inches wide over all and 9 inches high. The disks are 4 inches in diameter and 3/64 of an inch thick, with the speed of the driven shaft 400 revolutions per minute. It is designed to be entirely inclosed and runs in an oil bath.

This device is manufactured by the T. C. Dill Machine Company, Philadelphia, Penn.

The McNaughton Sectional Grate

The construction of this grate is shown herewith. The top sections snap into place without the use of bolts, keys, etc. The old sections can be easily removed by breaking with a hammer when finally used up. The sections are made of a grade of iron intended to endure the continuous heat and variation in temperature of the furnace. The only parts subject to deterioration and loss are the short top sections. It is believed that this sectional construction saves more than half the cost of maintaining the grate, as it is possible to replace only that part actually burned up, and because they remain flat and do not warp.



M'NAUGHTON SECTIONAL GRATE

The construction of the bar with an under bearing gives a large per cent. of air opening and an even distribution of air. This grate is handled by C. P. Bassett, Charlotte, Mich.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Fuel Saving by Using a Feed-water Heater

I am burning 7000 pounds of coal per day, which costs $3.75 per ton. The feed water goes to the boiler at 60 degrees temperature. If a feed-water heater that will heat the water to 200 degrees is installed what per cent. of saving will there be?

J. D.

There will be a saving in fuel of 1 per cent. for each 11 degrees the temperature of the feed water is raised. In this case it is to be raised 140 degrees. Therefore, the percentage of saving will be the quotient of 140 divided by 11, or 12.7 per cent. A day's run of coal costs $13.12; a saving of 12.7 per cent. of this would be $1.58.

Two or Three Transformers on Three Phases

Which is better from the operating standpoint, three transformers or two, on three-phase alternating-current circuits?

T. J. S.

Three, in every respect. With three transformers, the regulation is uniform in all three divisions or "phases," and if one should break down, 60 per cent. of the normal total load can be carried on the other two as a makeshift. With two, the regulation under a motor load is very bad and the breakdown of one transformer would reduce the maximum allowable load to one-half the normal; moreover, it would change the distribution from three-phase to single-phase, thereby preventing the operation of three-phase motors.

Bricks Required to Build a Stack

How many bricks will be required to build a circular stack 6 feet in diameter at the bottom, 4 feet at the top and 70 feet in hight, with a 30-inch flue?

J. B. S.

The form of the stack is a frustrum of a cone, which calculated as solid and the cylindrical flue content subtracted would give the solid content of the stack. To calculate the content of a frustrum of a cone, add together the areas of the ends and a mean proportional between them and multiply this sum by one-third the length. The area of the 6-foot base is 28.27 square feet; of the 5-foot top, 19.63 square feet, and the mean proportional, 23.55, which added together make 71.45. This multiplied by 23.33 (one-third of 70) equals 1666.92 cubic feet, from which subtract 343 cubic feet, the content of the flue. This gives 1323.92 cubic feet of brickwork. Allowing 21 bricks per cubic foot of stack, it would require $21 \times 1323.92 = 27{,}802$ bricks to build the stack.

Boiler Braces Required

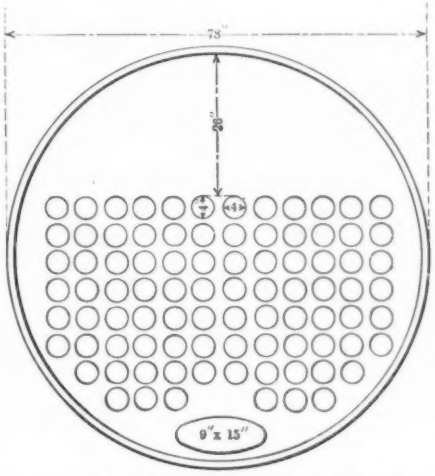
From the accompanying sketch of the front head of a 78-inch by 16-foot boiler, the thickness of head being ⅝ inch, will you kindly figure in plain arithmetic how many ½x3¾-inch solid steel McGregor braces it takes to brace it for 150 pounds working steam pressure?

F. W.

The area above the tubes to be braced is 988 square inches. At 150 pounds per square inch, the total pressure would be

$$988 \times 150 = 148{,}200$$

pounds. The stress on a brace should not exceed 6000 pounds per square inch of sectional area. Each ½x3¾-inch stay has a cross-sectional area of 1.875 square inches. This multiplied by 6000 gives 11,250 pounds as the stress allowed on each brace. The total pressure, 148,200 pounds, divided by 11,250, the pressure allowed on each brace, will give 12+ as the number of through braces to be used. If diagonal braces are used, the number will depend



WANTED, TO FIND NUMBER OF BRACES REQUIRED

on the angle they make with the head. At an angle of 60 degrees twice as many would be needed.

Can you tell me why my Corliss engine loses its vacuum and what makes the steam valves pound when this happens?

A. F. S.

It is the condenser, not the engine, that loses the vacuum, and the causes for this are legion, the chief of which are excessive air leaks and lack of sufficient condensing water. The pounding of the steam valves is caused by excessive compression when running noncondensing. The exhaust steam is at a much higher pressure and, compression beginning at the same point in the stroke, the compression carries the pressure in the cylinder above that in the steam chest, the steam valves are lifted from their seats and they fall back with a bang. The exhaust valves should be so set that no difference in the operation of the engine will be noticed whether running condensing or noncondensing. It frequently happens that the change of receiver pressure in a compound engine, caused by the loss of the vacuum, will make the low-pressure side of an engine pound on the centers when the valves do not lift. This is caused by excessive lead. For quiet running of condensing engines, either simple or compound, under all conditions of condenser service lead and compression should be avoided.

Pound in a Small Engine

I am running a small engine which pounds on the outer center. By putting my hand on the rod and pushing it against the crank face I can stop the pound. What is the cause of the pound and how can I cure it?

E. F. L.

Too much clearance between the brasses and the crank face and a lack of alinement cause the rod to slap against the crank face on the collar on the pin as the pressure changes from one side of the piston to the other. The engine should be put in perfect line and the clearance on the sides of the brasses reduced to a minimum.

Length of Connecting Rod

I have an engine that is complete except that it has no connecting rod. How can I get the length for a new rod?

H. H.

Push the piston to one end of the cylinder until it strikes the cylinder head. Make a mark on the guide where the crosshead rests. Then move the piston until it strikes the other cylinder head, and mark the guide as before. Put the crosshead exactly in the middle of its travel, and the distance from the center of the crosshead pin to the center of the crank shaft will be the proper length for the connecting rod. In engine design the connecting-rod length is almost universally some multiple of the crank length, usually five or six, although sometimes engines are seen with a connecting-rod length of only four cranks.

The Engineering Experiment Station of the University of Illinois has issued Bulletin No. 24, "The Modification of Illinois Coal by Low Temperature Distillation," by S. W. Parr and C. K. Francis. These experiments describe an attempt to remove from bituminous coals the heavy hydrocarbons and to produce a fuel essentially smokeless. The original impetus to the experiments was given by the anthracite strike of 1902, efforts then being made to produce artificially, from Illinois coals, material which would be sufficiently anthracitic in character to supply the demand for that type of fuel. Certain unexpected results were obtained in connection with the temperatures at which the oxidation of coal may be effected, and a large part of this work, therefore, is a description of this phase of the subject.

Improving the Contacts of Old Induction Motor Starters

By R. H. Fenkhausen

During the early development of the induction motor the starters supplied with the motors were equipped with double-throw knife switches, and there are thousands of these early starters still in use. The switch jaws were turned up from a solid bar and a slot was milled in one end of each, as in Fig. 1; the switch blades had spring washers riveted on, as in Fig. 2. There being little or no spring to this type of contact, serious burning results after the switch becomes worn.

There are more than a hundred motors in the plant of which the writer is chief electrician, and as most of them are provided with this type of starter, it became necessary after a time to develop a new type of contact to replace those burned

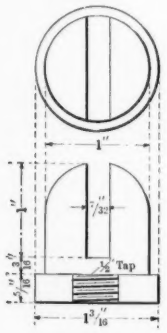


FIG. 1

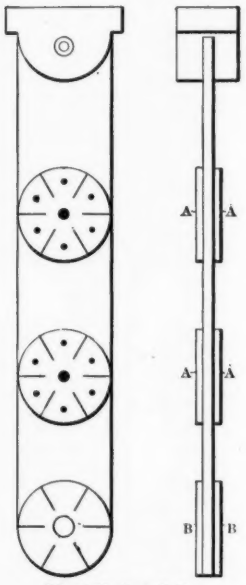


FIG. 2

out, and a description of this is given in the hope that it may be of value to others situated as the writer is. The same jaws were used, but they were milled out to the dimensions given in Fig. 3, and reversible clips were attached as shown in Fig. 4. The washers *A A* were removed from the blades, which now engage the spring clips directly. This type of contact has been in use on all our motors for more than twelve months and has given perfect satisfaction. In fact, it has never been

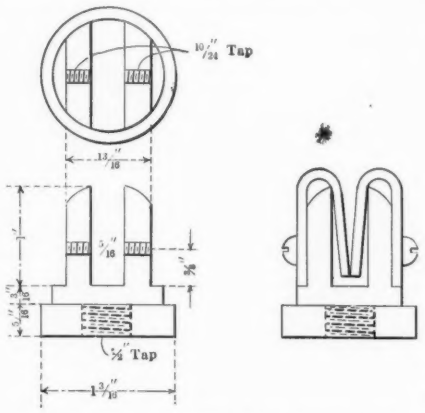


FIG. 3. THE IMPROVED JAW, WITH AND WITHOUT SPRINGS

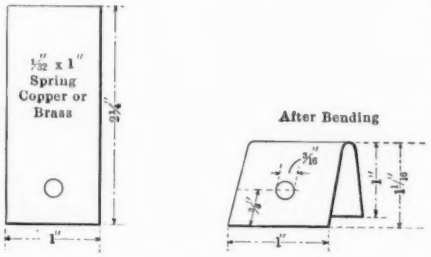


FIG. 4. ONE OF THE CONTACT SPRINGS

necessary to renew even the detachable clips.

The sizes given apply to the smaller type of starter, which is used with motors of 40 horsepower and under. The jaws are also applicable to the larger sizes of starter, and the writer will be glad to give the necessary data for such sizes to anyone desiring the information.

When a large number of starters are to be fitted up, as was the case in this plant, the cost may, by the use of jigs, etc., be reduced to about $1 per starter.

Annual Meeting of the A. S. M. E.

The twenty-ninth annual meeting of the American Society of Mechanical Engineers will be held December 1-4, in the Engineering Societies building, New York City. Among the papers which will be of interest to our readers are the following: "The Conservation Idea as Applied to the American Society of Mechanical Engineers," by M. L. Holman; "A Method of Obtaining Ratios of Specific Heat of Vapors," by A. R. Dodge; "The Total Heat of Saturated Steam," by Dr. Harvey N. Davis; "Fuel Economy Tests," by C. R. Weymouth; "An Automatic System for Firing Fuel Oil," by C. R. Weymouth; "Liquid Tachometers," by Amasa Trobridge; "An Averaging Instrument for Polar Diagrams," by Prof. W. F. Durand; "Reminiscences of a Gas Engine Designer," by L. H. Nash; "Possibilities of the Gasolene Turbine," by Prof. F. C. Wagner; "The Slipping Point of Rolled Boiler Tube Joints," by O. P. Hood and Prof. G. L. Christensen; "Tests on Friction Clutches for Power Transmission," by Prof. Richard G. Dukes.

Business Items

The Cornell Economizer Company has removed its offices to 55 DeLong building, corner of Thirteenth and Chestnut streets, Philadelphia.

Charles S. Hamner and Virginius D. Moody have opened a consulting-engineers' office at 25 Broad street, New York City, under the style of Hamner & Moody. They are well known in engineering circles, each having had excellent connections, the General Electric Company among others.

Manufacturers and dealers in engine- and boiler-room accessories would do well to send copies of their catalogs and other printed matter to Eduljee Dinshaw Bathiwala, 38 Tardeo road, Bombay, India, who has several steam plants, uses some American-made goods and would be glad to know about more of them.

The corporate title of the Dodge Coal Storage Company, of Philadelphia, has been changed to the J. M. Dodge Company. No changes, other than of name, are involved, the new title being adopted to avoid the limitations of the old in the extension of the company's operations into wider fields of engineering and contracting.

The Parker Boiler Company, Pennsylvania building, Philadelphia, Penn., is erecting two 100-horsepower boilers in the new Y. M. C. A. building at Milwaukee; two 267-horsepower for the University of Washington, Seattle, Wash., and one 203-horsepower for the *Philadelphia Inquirer*, at Philadelphia, the last named being a repeat order.

New Equipment

The city of Boone, N. C., contemplates construction of water-works.

The Plymouth (Mass.) Electric Light Company will enlarge its plant.

The Keich Company, Nettleton, Ark., contemplates establishing an ice plant.

The Denver (Colo.) City Tramway Company is planning to construct a new substation.

H. B. Porter, Sarasota, Fla., has been granted franchise to operate an electric-light system.

J. T. Thompson, Husum, Wash., is preparing to install a power plant to cost $10,000.

Plans have been prepared for a new power house for the John Piling Shoe Company, Lowell, Mass.

The Stigler (Okla.) Light and Power Company contemplates the installation of ice machinery.

The Pea River Power Company, Elba, Ala., is making arrangements to rebuild plant recently destroyed by fire.

It is reported that $20,000 bonds will be issued for the construction of water works at De Queen, Ark.

The Jasper (Fla.) Water and Light Company is said to have under consideration the purchase of another dynamo.

Do The Right Thing Right Now

¶ The right thing to do in a power plant is to provide some means of determining the exact amount of power developed for the quantity of fuel consumed.

¶ The American-Thompson Improved Indicator gives this information with perfect reliability.

Don't Take Chances

¶ The American-Thompson gives you diagrams which show conditions precisely as they are.

¶ By means of the New Improved Detent Motion you can take ten accurate Diagrams in the time ordinarily required for one.

¶ Besides this there are several other original features that are of utmost importance.

CIRCULAR 2-B
Contains detailed description.

BUY The American-Thompson Improved Indicator

American Steam Gauge & Valve Mfg. Co.,

208-220 CAMDEN STREET, BOSTON, MASS.

New York, 26 Cortlandt St. Atlanta, 835 Equitable Bldg. Chicago, 7-9 So. Jefferson St.
Pittsburg, Frick Building Annex. San Francisco, 247 Pine St.
Montreal, 444 St. James St. Los Angeles, 213 So. Los Angeles St.

The City Council, Heber, Ark., has granted franchise to C. F. Crosby to construct and operate a street railway.

Plans are being considered for enlarging the municipal electric light-plant and water works at Healdsburg, Cal.

The Marion (N. C.) Knitting Mill Company, recently incorporated, is erecting a building. Electric power will be used.

The Hotel Grunewald Company, New Orleans, La., will construct an electric plant for lighting, heating and power purposes.

It is reported that the Board of Regents, University of Texas, Austin, Texas, contemplates erecting a power plant.

The power house at the Oakwood mine of the White Oak Fuel Company at Scarbro, W. Va., was destroyed by fire.

The plant of the Keokuk (Iowa) Electric Railway and Power Company was badly damaged by the explosion of a flywheel.

Henry L. Reinhold, Jr., architect, Philadelphia, Penn., has prepared plans for a four-story cold storage and refrigerating plant.

The McCaffrey Water Motor and Power Company, Troy, N. Y., has commenced construction on plant. J. G. McCaffrey is president.

Hall Brothers have been granted franchise by the City Council, Newport, Ore., to construct and operate an electric-light plant and water-works system.

Bids will be received until November 24 by S. R. Sumner, city clerk, Wenatchee, Wash., for the construction of additions to and extensions of the municipal water works.

W. E. Keller, president of Globe Milling Company, Los Angeles, Cal., has purchased site at El Paso, Texas, on which to erect an ice and cold-storage plant to cost about $60,000.

Contract has been awarded Muralt & Company, New York, for the enlargement and improvements of the hydroelectric plant of the Riverside Electric Company, Riverside, L. I.

The Dayton, Springfield & Xenia Southern Railway Company has been incorporated to build an electric railway from Xenia to Wilmington and Cincinnati. T. A. Ferneding, Dayton, president.

The Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until November 14 for installing a coal and ash plant at the power plant at the Charlestown Navy Yard.

The Bureau of Yards and Docks, Navy Department, Washington, D. C., will open bids November 21 for constructing water mains, installing pumping machinery, etc., at the Navy Yard, Pensacola, Fla.

The Board of Water Commissioners, Canandaigua, N. Y., has requested an appropriation of $35,000 for purchasing two motor-driven centrifugal pumps with a capacity of about 2,500,000 gallons each.

Bids will be received at the office of the constructing quartermaster, Plattsburg Barracks, N. Y., until November 18 for the construction of a transformer station and installing an electrical lighting system.

The Red Deer (Alta) Railway Company, capitalized at $100,000, will, it is said, commence construction work in the spring. Power will be rented at first, but ultimately two power houses will be erected, one at Red Deer, the other at Coalbanks.

The Nebraska Traction & Power Company has been incorporated at Lincoln, Neb., to build an electric railway from Omaha to Mt. Ralston. Power station will be built at Ralston. Capital $2,000,000. Incorporators, M. Uhl, J. F. Emmert, W. D. Christ and others.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

ENGINEERS wanted to sell the Simplex pipe clamp for stopping leaky pipe joints and the Simplex blow-off valve for boilers in evenings among their fellow engineers on a large commission. Write! The Simplex Engineering Co., 326 Preston St., Phila., Pa.

WANTED—Mechanical draftsman, young man familiar with high-speed engines; excellent opportunity for the right party to work into leading position. To receive consideration give full details of experience, length of engagements, salary received, etc., etc. Box 53, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Position with manufacturing concern by man having technical education in steam engineering, and 12 years' experience. First class reference furnished upon request. Address "Engineer," 316 East Myrtle St., Rome, N. Y.

WANTED—Position as advertising manager. Have had years of experience in building catalogs, booklets, folders, etc., also have a practical knowledge of printing values and all details in connection therewith. I hold similar position at the present time, but for good reasons desire a change. Address A. R. M., 1457 Wilson Avenue, Chicago, Ill.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

BOILER TUBES CRACKING? Can stop or no pay; any boiler. Wm. Fulton Engineering Co., Office, 28 N. Canal St., Dayton, O.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

150 HORSE-POWER tandem compound Corliss engine, in good order; 16-ft. wheel; 24-in. face. F. W. Iredell, 11 Broadway, New York.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—Rights in a valuable invention. Variable speed changes for lathes, planes, drills, sharpeners, etc.; economical and efficient. Address William Wallace White, 309 Broadway, New York.

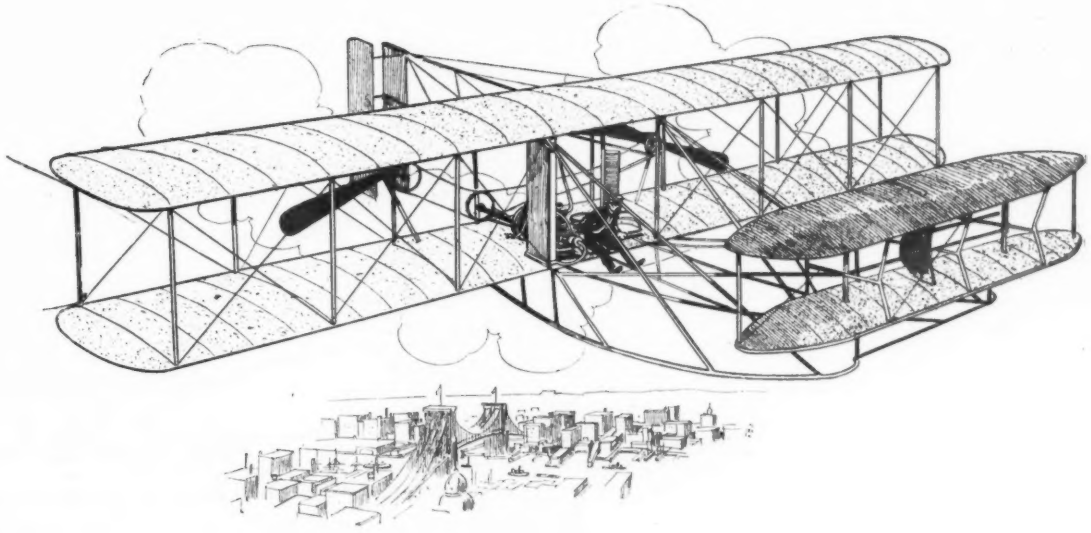
ONE 23x60 SINGLE-CYLINDER, double-acting Harris Corliss. Pendulum ball governor with sectional cast-iron flywheel, 18 feet by 38 inches; good order, requirements changed, electric power being used. Almond Mfg. Co., Ashburnham, Mass.

FOR SALE—We have for sale one 40-kilowatt, 250-volt direct current Electric Machinery Company belted generator, speed 700 r.p.m. We are installing an a.c. system of the same make and can deliver any time after December 1. The machinery is as good as new. Everett Aughenbaugh & Company, Waseca, Minn.

FOR SALE—Seven Sturtevant standard fuel economizers, four having 312 pipes or 52 sections of six pipes each; three having 336 pipes or 56 sections of six pipes each. Total, 2,256 pipes, or 28,308 square feet of heating surface, a water capacity of approximately 142,900 lb., designed for 190 lb. boiler pressure, and tested in the field at 200 lb. hydraulic pressure. Length lower floor section, 33' 6"; length upper floor section, 33' 10"; height of sections, 10' 2¼"; height over all, 12' 6". The economizers are complete in every respect. Have practically never been in service. Address Charles S. Shepard, 55 Duane Street, New York.

Alphabetical Index to Advertisers

	PAGE
Alberger Co., A. H	109
Alberger Condenser Co	101
Allan & Son, A	109
American Boiler Economy Co	106
American District Steam Co	94
American Engine Co	112
American Goetze-Gasket and Packing Co	72
American Injector Co	91
American School of Correspondence	67
American Steam Gauge and Valve Mfg. Co	55
American Steam Pump Co	102
Anchor Packing Co	74
Anderson Co., V. D	94
Armstrong Mfg. Co	79
Ashton Valve Co	80
Babcock & Wilcox Co	103
Ball-Cooley Engineering Co	109
Ball & Wood Co	80
Ball Engine Co	109
Baragwanath & Son, Wm	98
Barnes Co., W. F. & Jno	92
Bates Machine Co	99, 112
Beggs & Co., Jas	97
Berry Engineering Co	105
Bignall & Keeler Mfg. Co	82
Binghamton Boiler Compound Co	92
Bird-Archer Co	67
Bristol Co	116
Broomel, Schmidt & Steacy Co	107
Buckeye Boiler Skimmer Co	92
Buckeye Engine Co	110
Burt Mfg. Co	10
Cancos Mfg. Co	74
Canfield Mfg. Co	74
Carey Co., Philip	75
Carpenter & Co., Walter D	92
Chaplin-Fulton Mfg. Co	105
Chesterton Co., A. W	85
Clark Bros. Co	110
Climax Smoke Preventer Co	94
Cling-Surface Co	63
Continental Natural Gas Alcohol Co	63
Cook's Sons, Adam	90
Cooper Co., C. & G	112
C-O-Two Furnace Co	94
Crocker-Wheeler Co	80
Crosby-Steam Gage & Valve Co	61
Curtis & Curtis Co	81
Davis Regulator Co., G. M	106
Dean Bros. Steam Pump Works	103
Deane Steam Pump Co	102
Dearborn Drug & Chemical Works	5
De Laval Steam Turbine Co	102
De La Vergne Machine Co	109
Deming Co	101
d'Este Co., Julian	106
Detroit Leather Specialty Co	61
Detroit Lubricator Co	87
Diamond Rubber Co	69
Direct Separator Co	97
Dixon Crucible Co., Jos	90
Du Bois Iron Works	102
Eclipse Feed Water Heater & Purifier Co	101
Edge Moor Iron Co	104
Epping-Carpenter Co	101
Erie Mfg. and Supply Co	99
Eureka Packing Co	71
Fisher Governor Co	105
Fitchburg Steam Engine Co	111
Foos Gas Engine Co	107
Fort Wayne Electric Works	107
Foster Engineering Co	79
Gardner Governor and Separator Co	74
Garlock Packing Co	9
General Electric Co	113
General Specialty Co	85
Goulds Mfg. Co	102
Green Engineering Co	94
Green Fuel Economizer Co	98
Greene, Tweed & Co	91, 116
Griffith & Wedge Co	109
Griscom-Spencer Co	100
Hammel Oil Burner Co	94
Harrisburg Pipe and Pipe Bending Co	100
Harrison Safety Boiler Works	57
Hawk-Eye Compound Co	92
Heine Safety Boiler Co	103
Hershey Machine and Fdry. Co	98
Hill Publishing Co	65, 66, 76, 88
Hoffman, Geo. W	108
Homestead Valve Mfg. Co	61
Hoppes Mfg. Co	100
Houchin-Aiken Co	74
Houghton & Co., E. F	73
Huyette Co., Paul B	80
International Correspondence Schools	95
Jeffrey Mfg. Co	93
Jenkins Bros	77
Johns-Manville Co., H. W	63
Johnson Co., Henry	72
Keeler Co., E	104
Kewanee Boiler Co	104
Keystone Lubricating Co	3, 115
Kitts Mfg. Co	96



GETTING THERE

You can get there, with a little help from us, if you want to profitably utilize your available exhaust steam.

First, your boilers ought to have a plentiful supply of hot water,—water at a temperature of say 208 to 210 degrees F. So long as there is sufficient steam a Cochrane Heater will give you the full temperature to which you are entitled, no matter whether you clean the heater or whether you don't; that is, just as long as you can get the steam and the water into the heater.

Incidentally you are going to get some other benefits at the same time, such as the saving of the exhaust condensed in accomplishing the heating, the opportunity of bringing back and utilizing all live steam drips and returns; all of which water displaces that much fresh raw water; and you are going to improve the quality of your boiler feed supply.

If yours is a condensing plant, and you have only a limited quantity of exhaust steam—say only enough for a closed heater to raise the temperature to 180 degrees, then you can hardly afford to be without a Cochrane Heater, for it will give you 13 or 14 degrees more temperature than the closed heater, while delivering the full quantity of water and using the same limited quantity of exhaust. This little difference just figures out about 1½% of your entire fuel bill, in favor of your using the Cochrane Heater.

Now, if you have any other use for your exhaust, then we can be of still greater assistance. If besides supplying your boilers you will require a lot of hot water for some industrial purposes, we can furnish you a heater that will give you all the extra water you want, and at such a temperature as the amount of exhaust available entitles you to.

Again, we can help you if it is a case of keeping oil out of your piping, out of your radiators, and out of your condensed exhaust. Our Cochrane Oil Separators will give you this protection, because they are doing it in 8,000,000 or 10,000,000 H.P. of other plants.

Besides which you will have right at your command the benefit of all the experience that we have gained in making thousands of installations of this character.

Let us know what you have got and what you want to accomplish, and it won't be long before you get there.

HARRISON SAFETY BOILER WORKS,

17TH AND CLEARFIELD STS., PHILADELPHIA, PA.

	PAGE
Lagonda Mfg. Co	83
Lammert & Mann	79
Leavitt Machine Co	82
Liberty Mfg. Co	84
Lippincott Steam Specialty & Supply Co	61
Loew Mfg. Co	96
Lunkenheimer Co	89
McClave-Brooks Co	7
McCrea & Co., James	82
McGowan Co., Jno. H	103
McLeod & Henry Co	1
Martin Grate Co	94
Mason Regulator Co	79
Mayville Specialty Mfg. Co	94
Mercer Rubber Co	74
Minneapolis Steel and Machinery Co	114
Morehead Mfg. Co	95
Morrin Climax Boiler Co	103
Mound Tool and Scraper Co	63
Murphy Iron Works	94
Myers & Bro., F. E	103
National India Rubber Co	74
National Pipe Bending Co	99
National Tube Co	82
Neemes Bros	93
New York Belting and Packing Co., Ltd	70
Northern Electrical Mfg. Co	109
Ohio Blower Co	85
Ohio Brass Co	79
Ohio Injector Co	91
Oil Well Supply Co	105
Oster Mfg. Co	61
Parker Boiler Co	104
Patterson & Co., Frank L	98
Peerless Rubber Mfg. Co	68
Penberthy Injector Co	8
Pennsylvania Flexible Metallic Tubing Co	85
Philadelphia Lubricator and Mfg. Co	87
Phoenix Iron Works Co	111
Pierce Co., Wm. B	2
Pittsburgh Gage & Supply Co	97
Pittsburgh Valve and Fittings Co	78
Pittsburgh Valve, Foundry and Construction Co	79
Platt & Co., Jno	95
Powell Co., Wm	87
Power Specialty Co	104
Presbrey Fire Brick Works	94
Providence Engr. Works	109
Quaker City Rubber Co	4
Randle Machinery Co	108
Reeves Pulley Co	63
Reliance Gauge Column Co	80
Restein Co., Clement	73
Rhoads & Sons, J. E	87
Ridgway Dynamo and Engine Co	110
Riverside Engine Co	108
Robb. Mumford Boiler Co	105
Robertson & Sons, Jas. L	71
Robins New Conveyor Co	86
Rust Boiler Co	104
St. John, G. C	97
Saginaw Mfg. Co	86
Salamander Grate Bar Co	94
Sargent Steam Meter Co	108
Sawyer Belting Co	86
Schaeffer & Budenberg Mfg. Co	78
Schieren Co., Chas. A	86
Schuchardt & Schutte	63
Schutte & Koerting Co	103
Shepherd Engineering Co	109
Shultz Belting Co	86
Simplex Engineering Co	82
Sirocco Engineering Co	93
Skinner Engine Co	110
Smooth-On Mfg. Co	6
Southwark Foundry and Machine Co	108
Starrett Co., L. S	116
Steel Mill Packing Co	74
Stephenson Mfg. Co	85
Stewart Heater Co	99
Strong, Carlisle & Hammond Co	96
Struthers-Wells Co	108
Sturtevant Co., B. F	113
System Co	61
Toledo Pipe Threading Machine Co	82
Trill Indicator Co	87
Trimont Mfg. Co	75
Triumph Electric Co	107
Triumph Ice Machine Co	107
Underwood & Co., H. B	111
Union Steam Pump Co	103
U. S. Mineral Wool Co	63
Vanda Co	69
Vilter Mfg. Co	109
Vogt Machine Co., Henry	104
Walch & Wyeth	108
Walton Co., F. S	86
Warren Steam Pump Co	101
Watertown Engine Co	109
Watson & McDaniel Co	96
Watson-Stillman Co	67
Webster & Co., Warren	59
Westinghouse Machine Co	92
Wetherill & Co., Robert	111
Wheeler Condenser & Eng. Co	101
Whitlock Coil Pipe Co	100
Wickes Boiler Co	104
Wiederholdt Construction Co	94
Wilkinson Mfg. Co	93
Williams & Co., J. H	75
Williams Foundry and Machine Co	87
Williams Valve Co., D. T	95
Wing Mfg. Co., L. J	94
Yale & Towne Mfg. Co	93
York Mfg. Co	109

Classified Index to Articles Advertised

Air Compressors

Deane Steam Pump Co., Holyoke, Mass.
McGowan Co., John H., Cincinnati, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Union Steam Pump Co., Battle Creek, Mich.
Westinghouse Traction Brake Co., Pittsburg, Pa.
York Mfg. Co., York, Pa.

Alarms, High and Low Water

Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Reliance Gauge Column Co., Cleveland, O.

Alcohol Distillery Apparatus

Continental Natural Gas Alcohol Co., Wheeling, W. Va.

Arch, Back Combustion Chamber

McLeod & Henry Co., Troy, N. Y.
Mayville Specialty Mfg. Co, Mayville, Wis.

Arch, Boiler

McLeod & Henry Co., Troy, N. Y.

Arch, Boiler Door

Mayville Specialty Mfg. Co., Mayville, Wis
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Asbestos Goods

Carey Co., Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.
Restein Co., Clement, Philadelphia, Pa.

Bars, Cylinder Boring

Underwood & Co., H. B., Phila., Pa.

Batteries, Storage

Westinghouse Machine Co., Pittsburg, Pa.

Belt Fasteners

Bristol Company, Waterbury, Conn.

Belting

Anchor Packing Co., Philadelphia, Pa.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Reeves Pulley Co., Columbus, Ind.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa

Belting — *Continued.*

Robins New Conveyor Co., New York.
Sawyer Belting Co., New York.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Benders, Hydraulic

Watson-Stillman Co., New York.

Bending, Pipe

Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Bends, Pipe

Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Blocks, Chain

Yale & Towne Mfg. Co., New York.

Blowers

Beggs & Co., James, New York
De Laval Steam Turbine Co., Trenton, N. J.
Green Fuel Economizer Co., Matteawan, N. Y.
McClave-Brooks Co., Scranton, Pa.
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Blowers, Furnace

McClave-Brooks Co., Scranton, Pa.

Boiler Skimmers

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Boilers, Second Hand

Wickes Boiler Co., Saginaw, Mich.

Boilers, Tubular

Babcock & Wilcox Co., New York.
Beggs & Co., James, New York.
Edge Moor Iron Co., Edge Moor, Del.
Griffith & Wedge Co., Zanesville, O
Heine Safety Boiler Co., St. Louis, Mo.
Keeler & Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Oil Well Supply Co., Oswego, N. Y.
Phoenix Iron Works Co., Meadville, Pa.
Robb-Mumford Boiler Co., South Framingham, Mass.
Struthers-Wells Co., Warren, Pa.

Boilers, Tubular — *Continued.*

Vilter Mfg. Co., Milwaukee, Wis.
Wetherill & Co., Robert, Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Boilers, Water Tube

Babcock & Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor, Del.
Heine Safety Boiler Co., St. Louis, Mo.
Keeler Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Morrin Climax Boiler Co., Brooklyn, N. Y.
Oil Well Supply Co., Oswego, N. Y.
Parker Boiler Co., Philadelphia, Pa.
Phoenix Iron Works Co., Meadville, Pa.
Robb-Mumford Boiler Co., South Framingham, Mass.
Rust Boiler Co., Pittsburg, Pa.
Struthers-Wells Co., Warren, Pa.
Vogt Machinery Co., Henry, Louisville, Ky.
Wetherill & Co., Robt., Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Books

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Text Book Co., Scranton, Pa.
System Co., Chicago, Ill.

Boosters

Ridgway Dynamo & Engine Co., Ridgway, Pa.

Brick, Fire

C-O-Two Furnace Co., Syracuse, N. Y.
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Building Materials, Fireproof

Carey Co., The Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.

Calorimeters

Sargent Steam Meter Co., Chicago, Ill.

Castings, Brass and Iron

Homestead Valve Mfg. Co., Pittsburg, Pa.
McClave-Brooks Co., Scranton, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Castings, General

Neemes Bros., Troy, N. Y.

Castings, Malleable

Jeffrey Mfg. Co., Columbus, O.

Cement, Asbestos

Johns-Manville Co., H. W., New York.
N. Y. Belting & Packing Co., New York.

Cement, Boiler

Smooth-On Mfg. Co., Jersey City, N. J.

Chimneys

Wiederholdt Construction Co., Chicago, Ill.

Chimneys, Reinforced Concrete

Wiederholdt Construction Co., Chicago, Ill.

Clamp, Steam Joint

McCrea & Co., James, Chicago, Ill.

Clamp, Pipe

McCrea & Co., James, Chicago, Ill.
Simplex Engineering Co., Philadelphia, Pa.

Cleaners, Tube

Buckeye Boiler Skimmer Co., Toledo, Ohio.
Chesterton Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.
General Specialty Co., Buffalo, N. Y
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
McCrea & Co., James, Chicago, Ill.
Pierce Co., Wm. B., Buffalo, N. Y.
Robertson & Sons, Jas. L., New York.
Stewart Heater Co., Buffalo, N. Y

Clocks

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Clutches, Friction

Reeves Pulley Co., Columbus, Ind.
Williams Fdry. & Mach. Co, Akron, Ohio.

Cocks, Blow-Off

Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Cocks, Gage

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Huyette Co., P. B., Philadelphia, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Right By Analysis
Right By Thermometer

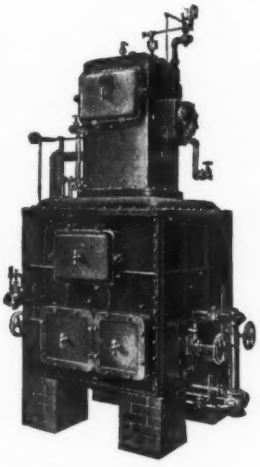
Is The Feed Water

Webster Feed Water Heater, Purifier and Filter

Which Is Supplied By

Webster Feed Water Heaters and Chemical Purifiers

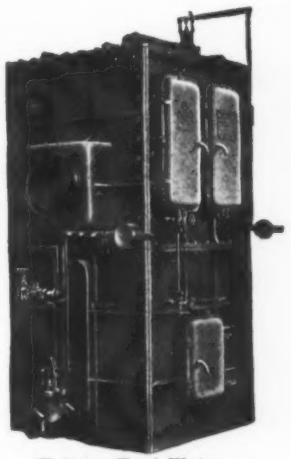
The thermometer will show that the water fed into a boiler from a Webster Heater is at the highest possible temperature. An analysis of that water will show that it contains no impurities that can harm the boiler or lower its efficiency.



Webster Chemical Purifier

Until we *know*, by careful investigation, that a "Webster" will gain those ends at minimum cost we do not install our heater. Each one is applied to meet the special conditions of the buyer's plant. Our chemists analyze the water supply, our engineers study the requirements and prescribe the Heater. We guarantee that it will give perfect satisfaction—then we install it. Does that plan appeal to you?

The Chemical Purifier Booklet is 12-C;
The Heater Booklet, 12-F.



Webster Feed Water Heater

WARREN WEBSTER & COMPANY
CAMDEN, NEW JERSEY

19

Cocks, Gage—*Continued.*
Reliance Gauge Column Co., Cleveland, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cocks, Steam
Homestead Valve Mfg. Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Compound, Boiler
Binghamton Boiler Compound Co., Binghamton, N. Y.
Bird-Archer Co., New York.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Dearborn Drug & Chemical Co., Chicago, Ill.
Hawk-Eye Compound Co., Chicago, Ill.
Johns-Manville Co., H. W., New York.

Compound, Lubricating
Cook's Sons, Adam, New York.
Houghton & Co., E. F., Philadelphia, Pa.

Condensers
Alberger Condenser Co., New York
Baragwanath & Son, Wm., Chicago, Ill.
Deane Steam Pump Co., Holyoke, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Wheeler Condenser and Engineering Co., New York.

Condensers, Gas
Phoenix Iron Works Co., Meadville, Pa.

Consumers, Smoke
Climax Smoke Preventer Co., Boston, Mass.

Controllers, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa

Controllers, Feed Water
American Boiler Economy Co., Philadelphia, Pa.

Cooling Apparatus, Air
De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.

Cooling Towers
Alberger Condenser Co., New York.
Baragwanath & Sons, Wm., Chicago, Ill.
Wheeler Condenser and Engineering Co., New York.

Correspondence Schools
American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa,

Couplings, Clutch
Williams Fdry. & Mach. Co., Akron, Ohio

Covering, Pipe and Boiler
Carey Co., Philip, Cincinnati, O.
Houghton & Co., E. F., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
U. S. Mineral Wool Co., New York.

Covering, Pulley
Houghton & Co., E. F., Philadelphia, Pa.

Crabs
Yale & Towne Mfg. Co., New York.

Cranes
Yale & Towne Mfg. Co., New York.

Die Stocks
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.

Draft Apparatus, Mechanical
Green Fuel Economizer Co., Matteawan, N. Y.
Wing Mfg. Co., L. J., New York.

Dressing, Belt
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.
Johnson Co., Henry, Jersey City, N.J.
Rhoads & Son, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.
Stephenson Mfg. Co., Albany, N. Y.
Walton Co., F. S., Philadelphia, Pa.

Dressing, Rope
Cling-Surface Co., Buffalo, N. Y.

Drills, Upright
Barnes Co., W. F. & John, Rockford, Ill.

Dynamos
Clark Bros. Co., Belmont, N. Y.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Educational
American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Ejectors
Beggs & Co., James, New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.

Engineers, Electrical
Northern Electrical Mfg. Co., Madison, Wis.

Engines, Corliss
Bates Machine Co., Joliet, Ill.
Beggs & Co., James, New York.
Cooper Co., C. & G., Mt. Vernon, O.
Griffith & Wedge Co., Zanesville, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Providence Eng. Works, Providence, R. I.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Watertown Engine Co., Watertown, N. Y.
Wetherill & Co., Robert, Chester, Pa.
Wheeler Condenser & Engineering Co., New York.

Engines, Gas and Gasolene
Alberger Co., A. H., Buffalo, N. Y.
Buckeye Engine Co., Salem, Ohio.
De La Vergne Machine Co., New York.
Du Bois Iron Works, Du Bois, Pa.
Foos Gas Engine Co., Springfield, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, High Speed
American Engine Co., Bound Brook, N. J.
Ball Engine Co., Erie, Pa.
Bates Machine Co., Joliet, Ill.
Buckeye Engine Co., Salem, Ohio.
Clark Bros. Co., Belmont, N. Y.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Eng. Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Phoenix Iron Works Co., Meadville, Pa.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Philadelphia, Pa.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Medium and Low Speed
Ball Engine Co., Erie, Pa.
Buckeye Engine Co., Salem, Ohio.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Mach. Co., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Oil
De La Vergne Machine Co., New York.

Engines, Rotary
Ball-Cooley Engineering Co., New York.

Engines, Steam
Ball & Wood Co., Elizabethport, N. J.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

Exhaust Heads
Burt Mfg. Co., Akron, O.
Gardner Gov. & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Ohio Blower Co., Cleveland, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Fans, Electric
Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Triumph Electric Co., Cincinnati, O.
Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

Fans, Exhaust and Ventilating
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.

Fans, Mine Ventilating
Jeffrey Mfg. Co., Columbus, O.

Feeders, Boiler
American Boiler Economy Co., Philadelphia, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Lunkenheimer Co., Cincinnati, O
Myers & Bro., F. E., Ashland, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Filters, Feed Water
Beggs & Co., James, New York.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Keystone Chemical Co., Philadelphia, Pa.

Filters, Oil
Burt Mfg. Co., Akron, O.
Houghton & Co., E. F., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Filtration and Softening Plants
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Harrison Safety Boiler Wks., Philadelphia, Pa.

Fittings, Ammonia
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, O.
York Mfg. Co., York, Pa.

Fittings, Boiler
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Fittings, Flange, High or Low Pressure
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Fittings, Hydraulic
Watson-Stillman Co., New York.

Fittings, Pipe
Triumph Ice Machine Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, O.

Flanges, Welded
Ball & Wood Co., Elizabethport, N. J.

Floats
Anderson Co., V. D., Cleveland, O.
Reliance Gauge Column Co., Cleveland, O.

Flue Gas Analysis Instruments
Pierce Co., Wm. B., Buffalo, N. Y.

Fuel Economizers
Green Fuel Economizer Co., Matteawan, N. Y.

Furnace Tile
C-O-Two Furnace Co., Syracuse, N. Y.

Furnaces
Murphy Iron Works, Detroit, Mich.

Furnaces, Smokeless
McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Penn.

Gage Glasses
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Chesterton Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.

Gage Testing Outfit
American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gages
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.
Huyette Co., Paul B., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

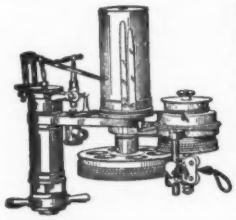
Gages, Ammonia
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Draft
Sargent Steam Meter Co., Chicago, Ill.

Gages, Pressure
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Gages, Recording
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Gages, Vacuum
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.



WHAT! NO INDICATOR?

Don't you know that I can give you a fine up-to-date outfit, new, from $25.00 up, and that I will let you pay a part of it acting as my agent in your spare time?

I will give you a thorough course of indicator instruction with a fine indicator to practice with for $5.00 per mo. Catalog?

Extra ¼ in. Area Cyl. for Ammonia, Gas Engine and high pressure work.

A. C. LIPPINCOTT, Newark, N. J.

FOR SALE The best valves that money can buy at any price—

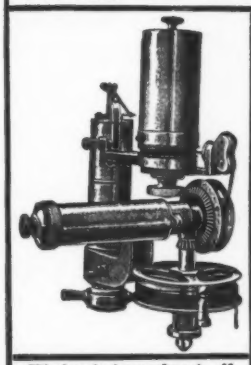
HOMESTEAD VALVES

Quickest acting, simplest, easiest acting and most durable made. One quarter turn opens or closes.

HOMESTEAD VALVE MFG. CO.,

Brass Founders. **PITTSBURG, PA.**

THERE IS BUT ONE **BEST INDICATOR**



The Crosby Indicator

(with either inside or outside spring)

TRADE MARK CROSBY

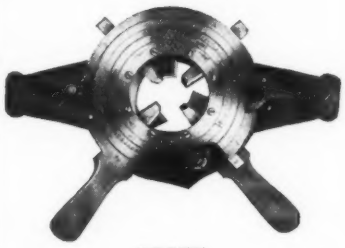
With CROSBY REDUCING WHEEL **IS A PERFECT COMBINATION**

In Making IMPORTANT TESTS of power plants IT IS THE ONE relied upon

NO ENGINEER should risk his REPUTATION with any other instrument

Highest Awards at all World Fairs

CROSBY STEAM GAGE & VALVE CO.
Boston New York Chicago London



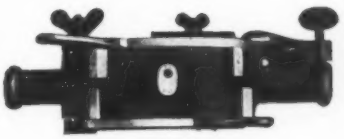
FRONT

Do You Cut

¼, ⅜, ½, ¾, 1-inch PIPE?

Then TRY THIS TOOL.

It will cut any size thread.
No loose bushings.
No resetting for each cut.
No turning back over the threads.
No crooked threads, because the guides will fit any size pipe.



SIDE

The Oster Manufacturing Co.

21 Schiely Street,
Cleveland, Ohio, U. S. A.

Will You Accept This Business Book if We Send it Free?

Sign and mail the coupon below. Send no money. Take no risk.

One hundred and twelve of the world's master business men have written ten books—2,193 pages—1,497 vital business secrets. In them is the best of all that they have been able to squeeze from their own costly experience about

—Factory Systems
—Power Costs
—Power House Records
—Fuel Economy
—Depreciation
—Cost-Cutting
—Organization
—Systematizing
—Purchasing
—Credits
—Collections
—Accounting
—Time-keeping
—Cost-keeping
—Advertising
—Correspondence
—Salesmanship
—Position-Getting
—Position-Holding
—Man-Handling
—Man-Training
—Business Generalship
—Competition Fighting

and hundreds and hundreds of other vital business subjects.

A 9,059-word booklet has been published describing, explaining, picturing the work. Pages 2 and 3 tell about managing businesses great and small; pages 4 and 5 deal with credits, collections and with rock-bottom purchasing; pages 6 and 7 with handling and training men; pages 7 to 12 with salesmanship, with advertising, with the marketing of goods through salesmen, dealers and by mail; pages 12 to 15 with the great problem of securing the highest market price for your services—no matter what your line; and the last page tells how you may get a complete set—bound in handsome half morocco, contents in colors—for less than your daily smoke or shave, almost as little as your daily newspaper.

Will you read the book if we send it free? Send no money. Simply sign the coupon

The System Co., 151-153 Wabash Ave., Chicago

If there are, in your books, any new ways to increase my business or my salary, I should like to know them. So send on your 16-page free descriptive booklet. I'll read it.

Name _____

Address _____

Business _____

Position _____

WEARWELL LEATHER PACKINGS

ALWAYS THE SAME.

Made in all sizes for Hydraulic and Compressed Air Machines.

Write for Catalog and Samples.

DETROIT LEATHER SPECIALTY CO., INC.,

175 Beecher Avenue, Detroit, Mich.

Gages, Water

Ohio Brass Co., Mansfield, O.

Gas Producers

Broomell, Schmidt & Steacey Co., York, Pa.
De La Vergne Machine Co., New York.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Westinghouse Mach. Co., Pittsburg, Pa.

Gaskets

American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Brandt, Randolph, New York.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
National India Rubber Co., Bristol, R. I.
N. Y. Belting & Packing Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Smooth-On Mfg. Co., Jersey City, N. J.
U. S. Mineral Wool Co., New York.

Gaskets, Copper

Restein Co., Clement, Philadelphia, Pa.
U. S. Mineral Wool Co., New York.

Generating Sets

American Engine Co., Bound Brook, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Foos Gas Engine Co., Springfield, Ohio.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Generating Units

Ridgway Dynamo & Engine Co., Ridgway, Pa.

Governors, Pump

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Indianapolis, Ind.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Gardner, Governor & Separator Co., Quincy, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.

Graphite

Carpenter Co., W. D., New York.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.

Grates

Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.
Salamander Grate Bar Co., New York.

Grates, Clinker Cutting

Neemes Bros., Troy, N. Y.

Grates, Shaking and Dumping

McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.
Neemes Bros., Troy, N. Y.

Grates, Stationary

Neemes Bros., Troy, N. Y.

Grease

Carpenter & Co., W. D., New York
Cook's Sons, Adam, New York.
Houghton & Co., E. F., Philadelphia, Pa.
Keystone Lubricating Co., Philadelphia, Pa.

Heaters, Feed Water

Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Bates Machine Co., Joliet, Ill.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Erie Mfg. & Supply Co., Erie, Pa.
Griscom-Spencer Co., New York
Harrison Safety Boiler Wks., Philadelphia, Pa.
Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill
Loew Mfg. Co., Cleveland, O.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., F. L., New York.
Phoenix Iron Works Co., Meadville, Pa.
Stewart Heater Co., Buffalo, N. Y.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser and Engineering Co., New York.
Whitlock Coil Pipe Co., Hartford, Conn.
Wickes Boiler Co., Saginaw, Mich

Heating, District Steam

American District Steam Co., Lockport, N. Y.

Heating and Ventilating Apparatus

Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Webster & Co., Warren, Camden, N. J.

Hoists, Electric

Yale & Towne Mfg. Co., New York.

Hoists, Hand

Yale & Towne Mfg. Co., New York.

Hose, Air and Oil

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Hose, Steam and Water

Anchor Packing Co., Philadelphia, Pa.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Indicators, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Indicators, Gas Engine

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Indicators, Hydraulic

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Speed

American Steam Gauge and Valve Mfg Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Starrett Co., L. S., Athol, Mass.

Indicators, Steam Engine

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, James L., New York.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Trill Indicator Co., Corry, Pa.

Injectors

American Injector Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Mach. Co., Cincinnati, O.
Schutte & Koerting Co., Philadelphia, Pa.

Insulation

Johns-Manville Co., H. W., New York.

Jacks, Hydraulic

Watson-Stillman Co., New York.

Joints, Pipe

Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Lacing, Belt

Bristol Co., Waterbury, Conn.

Lamps, Arc and Incandescent

Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Locks

Yale & Towne Mfg. Co., New York.

Lubricants

Carpenter Co., W. D., New York.
Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Philadelphia, Pa.

Lubricators

Cook's Sons, Adam, New York.
Chesterton Co., A. W., Boston, Mass.
Detroit Lubricator Co., Detroit, Mich.
Greene, Tweed & Co., New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Lubricator Co., Wadsworth, O.
Philadelphia Lubricator & Mfg. Co., Philadelphia, Pa.
Powell Co., Wm., Cincinnati, Ohio.

Machinery, Coal and Ash Handling

Jeffrey Mfg. Co., Columbus, O.

Machinery, Conveying

Jeffrey Mfg. Co., Columbus, O.

Machinery, Crank Pin Turning

Underwood & Co., H. B., Philadelphia, Pa.

Machinery, Ice and Refrigerating

De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.
Vilter Mfg. Co., Milwaukee, Wis.
York Mfg. Co., York, Pa.

Machinery, Second Hand

Randle Mach. Co., Cincinnati, O.

Machines, Blue Printing

Buckeye Engine Co., Salem, Ohio.

Machines, Milling, Portable

Underwood & Co., H. B., Philadelphia, Pa.

Machines, Pipe Threading

Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, O.

Machines, Pipe Threading —*Continued.*

Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Machines, Reseating, Flue Cap

Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.

Machines, Reseating, Valve

Leavitt Mach. Co., Orange, Mass.

Mats and Matting

Mercer Rubber Co., Hamilton Square, N. J.

Metal, Anti-friction

Allan & Son, A., New York.
Reeves Pulley Co., Columbus, Ind
St. John, G. C., New York.

Metal, Babbit

Allan & Son, A., New York.

Meters, Steam

Sargent Steam Meter Co., Chicago, Ill.

Motors, Electric

Clark Bros. Co., Belmont, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Oil Burners

Hammel Oil Burner Co., Los Angeles, Cal.

Oil and Grease Cups

Cook's Sons, Adam, New York.
Greene, Tweed & Co., New York.
Keystone Lubricating Co., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, O.
Philadelphia Lubricator & Mfg. Co., Philadelphia, Pa.
Powell Co., Wm., Cincinnati, Ohio.
Williams Valve Co., D. T., Cincinnati, O.

Oilers

Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Oiling Systems

Burt Mfg. Co., Akron, O.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa

Oils

Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Houghton & Co., E. F., Philadelphia, Pa.

Packing, Asbestos

Diamond Rubber Co., Akron, Ohio.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Philadelphia, Pa.

Packing, Flange

American Goetze-Gasket & Packing Co., New York.
Carey Co., The Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Eureka Packing Co., New York.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Houghton & Co., E. F., Philadelphia, Pa.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.
Vanda Co., New York.

THE BEST KIND OF FIRE PROTECTION

Fireproof construction is better fire protection to a building than any amount of fire insurance. By covering buildings with J-M ASBESTOS ROOFING it protects them from fire *at no extra cost*. It has the highest fire-resisting properties, because made of a fire-proof, indestructible mineral — *Asbestos*. No other roofing on the market offers such protection as

J-M Asbestos Roofing

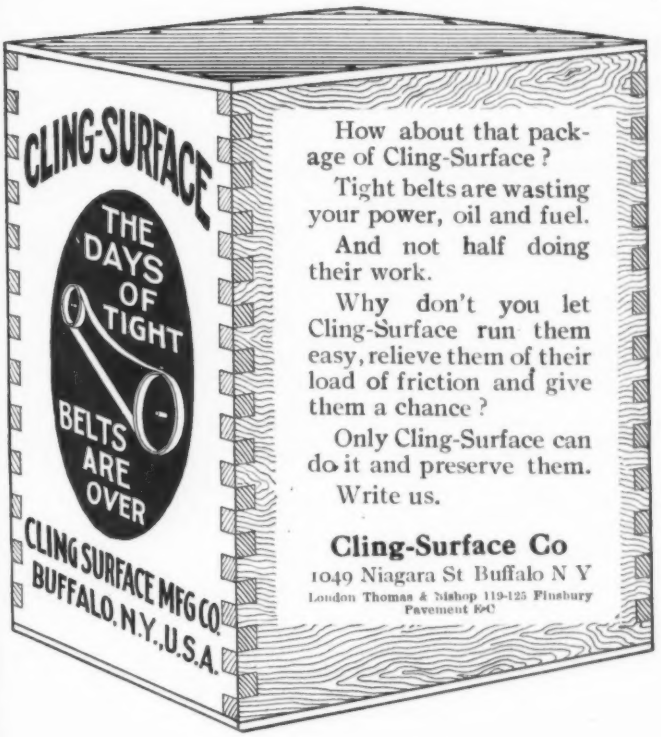
as other ready roofings are made of wool felt, rag stock, paper, shoddy, coal tar and other highly inflammable materials, which are an actual menace to a building instead of a protection. It is the "cheapest-per-year" roofing, because it requires no coating or painting to preserve it. The first cost is the only expense. It resists fire, rot, rust and wear and is the only *permanently durable* prepared roofing. Adapted to all climates and weather conditions.

Write nearest Branch for Samples and Catalog.

H. W. JOHNS-MANVILLE CO.

New York, Chicago, Boston, Philadelphia, Milwaukee, St. Louis, Pittsburg, Cleveland, Buffalo, Detroit, Baltimore, New Orleans, Kansas City, Minneapolis, San Francisco, Los Angeles, Seattle, Dallas, Toronto, London

891



How about that package of Cling-Surface?

Tight belts are wasting your power, oil and fuel.

And not half doing their work.

Why don't you let Cling-Surface run them easy, relieve them of their load of friction and give them a chance?

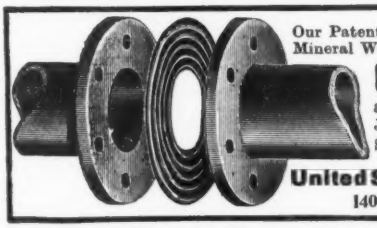
Only Cling-Surface can do it and preserve them.

Write us.

Cling-Surface Co

1049 Niagara St Buffalo N Y

London Thomas & Bishop 119-125 Finsbury Pavement E C



Our Patented Mineral Wool **Pipe Covering and Copper Gaskets** Save Steam and Make Absolutely Tight Joints. Best and Cheapest. Samples Free.

United States Mineral Wool Co.

140 Cedar Street, New York

MOUND TOOLS. FOR THE ENGINE ROOM.

This cut represents our new set of 20 tools gotten up for use in the engine room. Strictly high-grade tools with all the good points of toolsmithing in their make-up. Conveniently arranged in finished Oak Case and every tool is guaranteed.

No. 20 Set of 20 Tools . . . $4.00.

Book "Engineers' Chums" free. Address Dept. B

MOUND TOOL AND SCRAPER CO.

1606-1608 N. BROADWAY, ST. LOUIS, U. S. A.

CARL VON HARTZFELT, M. C.,

Denatured Alcohol from Natural Gas.

Plans, specifications, estimates and supervision for

Continuous Industrial Alcohol Distillery Apparatus,

for light, heat and power purposes from natural gas and Portable Stills for vegetable waste matter. Economy and rapidity of construction a specialty. Unquestionable references.

ACTING DIRECTOR OF

THE CONTINENTAL NATURAL GAS ALCOHOL CO.,

WHEELING, W. VA., U. S. A.

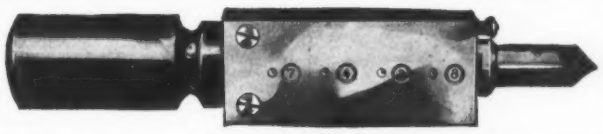
See Harper's Weekly, Oct. 3, 1908. Patent Serial No. 450,294—Aug. 25

"The Reeves" "C"

BEARING METALS

For all factory and machinery bearings it is better than any you have ever used. Sells for 25c a pound. Ask your dealer or write us.

REEVES PULLEY CO., Columbus, Indiana.



"Initiative" Revolution Counters

The old confusing way of reading the count on a dial is replaced by the simplicity of "Initiative" Counters. They register from 0 to 10,000 in either direction and are easily set to zero from any number. The count is read like an ordinary number.

SCHUCHARDT & SCHUTTE,

136 LIBERTY STREET, NEW YORK.

Packing, Hydraulic

Anchor Packing Co., Philadelphia, Pa.
Chesterton Co., A. W., Boston, Mass.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.
Robertson & Sons, Jas. L., New York.
Schieren Co., Chas. A., New York.
Steel Mill Packing Co., Detroit, Mich.
Vanda Co., New York.

Packing, Metallic

American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Canfield Mfg. Co., Philadelphia, Pa.
Houchin-Aiken Co., Brooklyn, N. Y.
Johns-Manville Co., H. W., New York.
Mercer Rubber Co., Hamilton Square, N. J.
Power Specialty Co., New York.
Restein Co., Clement, Phila., Pa.
Steel Mill Packing Co., Detroit, Mich.

Packing, Piston Rod

American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Canfield Mfg. Co., Philadelphia, Pa.
Carey Co., The Philip, Cincinnati, O.
Chesterton Co., A. W., Boston, Mass.
Diamond Rubber Co., Akron, Ohio.
Eureka Packing Co., New York.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Johns-Manville Co., H. W., New York.
National India Rubber Co., Bristol, R. I.
New York Belting and Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.
Robertson & Sons, Jas. L., New York.
Steel Mill Packing Co., Detroit, Mich.
Underwood & Co., H. B., Philadelphia, Pa.
Vanda Co., New York.

Packing, Pneumatic

Diamond Rubber Co., Akron, Ohio.
Houghton & Co., E. F., Philadelphia, Pa.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Phila., Pa.

Packing, Pump

National India Rubber Co., Bristol, R. I.

Packing, Pump Valve

Anchor Packing Co, Philadelphia, Pa.

Packing, Rod

Anchor Packing Co., Philadelphia, Pa.
Chesterton Co., A. W., Boston, Mass.

Pipe

See Tubing

Pipe Cutters

Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keller Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Planimeters

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.

Polish, Metal

Chesterton Co., A. W., Boston, Mass.
Hoffman, Geo. W., Indianapolis, Ind.

Presses, Hydraulic

Watson-Stillman Co., New York.

Publishers

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Correspondence Schools, Scranton, Pa.
System Co., Chicago, Ill.

Pulleys

Houghton & Co., E. F., Philadelphia, Pa.
Myers & Bro., F. E., Ashland, O.
Reeves Pulley Co., Columbus, Ind.
Saginaw Mfg. Co., Saginaw, Mich.

Pulleys, Clutch

Williams Fdry. & Mach. Co., Akron, Ohio.

Pumps

Blake Mfg. Co., Geo. F., New York.

Pumps, Air

American Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.
Wheeler Condenser & Engineering Co., New York.

Pumps, Boiler Feed

American Steam Pump Co., Battle Creek, Mich.
Epping-Carpenter Co., Pittsburg, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Warren Steam Pump Co., Warren, Mass.
Worthington, Henry R., New York.

Pumps, Centrifugal

Wheeler Condenser & Engineering Co., New York.
Worthington, Henry R., New York.

Pumps, Compound

American Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.

Pumps, Deep Well

American Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.

Pumps, Force-feed Oil

Greene, Tweed & Co., New York.
Lunkenheimer Co., Cincinnati, O.

Pumps, Hydraulic

American Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.
Watson-Stillman Co., New York.

Pumps, Mining

American Steam Pump Co., Battle Creek, Mich.

Pumps, Oil

American Steam Pump Co., Battle Creek, Mich.
Deming Co., The, Salem, O.
Detroit Lubricator Co., Detroit, Mich.
Du Bois Iron Wks., Du Bois, Pa.
Lunkenheimer Co., Cincinnati, Ohio.
Penberthy Injector Co., Detroit, Mich.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Pumps, Pressure

Deane Steam Pump Co., Holyoke, Mass.

Pumps, Steam

American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Du Bois Iron Works, Du Bois, Pa.
Epping-Carpenter Co., Pittsburg, Pa.
Gardner Gov. & Sep. Co., Quincy, Ill.
McGowan Co., John H., Cincinnati, O.

Pumps, Steam—*Continued.*

Myers & Bro., F. E., Ashland, O.
Stewart Heater Co., Buffalo, N. Y.
Union Steam Pump Co., Battle Creek, Mich.
Wheeler Cond. & Eng. Co., New York.

Pumps, Triplex

Deming Co., The, Salem, O.

Pumps, Turbine

Alberger Condenser Co., New York.
Worthington, Henry R., New York.

Pumps, Vacuum

American Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.
Wheeler Condenser & Engineering Co., New York.

Punches, Hydraulic

Watson-Stillman Co., New York.

Purifiers, Steam

Hoppes Mfg. Co., Springfield, O.

Purifiers, Water

Buckeye Boiler Skimmer Co., Toledo, Ohio.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O
Keystone Chemical Co., Phila., Pa.
Whitlock Coil Pipe Co., Hartford, Conn,

Pyrometers

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.

Re-cooling Plants

De La Vergne Machine Co., New York.
Schutte & Koerting Co., Philadelphia, Pa.

Recording Instruments

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Crosby Steam Gage and Valve Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Reducing Wheels

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Trill Indicator Co., Corry, Pa.

Regulators, Damper

Berry Engineering Co., Chester, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Kitts Mfg. Co., Oswego, N. Y.
Lagonda Mfg. Co., Springfield, O.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Watson & McDaniel Co., Phila., Pa.

Regulators, Feed Water

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.

Regulators, Pressure

American Boiler Economy Co., Philadelphia, Pa.
Davis Co., John, Chicago, Ill.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.

Regulators, Pressure—*Cont.*

Fisher Governor Co., Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Mason Regulator Co., Boston, Mass.
Ohio Brass Co., Mansfield, O.
Robertson & Sons, Jas. L., New York.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.

Regulators, Temperature

d'Este Co., Julian, Boston, Mass.

Regulators, Water

Foster Engineering Co., Newark, N. J.

Repairs, Engine and Pump

Underwood & Co., H. B., Philadelphia, Pa.

Revolution Counters

Schuchardt & Schutte, New York.

Rubber Goods

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Houghton & Co., E. F., Philadelphia, Pa.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.

Rust Preventers

Houghton & Co., E. F., Philadelphia, Pa.

Schools, Correspondence

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Separators, Steam and Oil

Baragwanath & Son, Wm., Chicago, Ill.
Beggs & Co., Jas., New York.
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Ohio Blower Co., Cleveland, O.
Patterson & Co., F. L., New York.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa
Robertson & Sons, Jas. L., New York.
Watson & McDaniel Co., New York.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser & Engineering Co., New York.
Whitlock Coil Pipe Co., Hartford, Conn.
Williams Valve Co., D. T., Cincinnati, O.

Sheathing

Carey Co., The Philip, Cincinnati, Ohio.
Johns-Manville Co., H. W., New York.

Skylights

Burt Mfg. Co., Akron, O.

Smoke Preventers

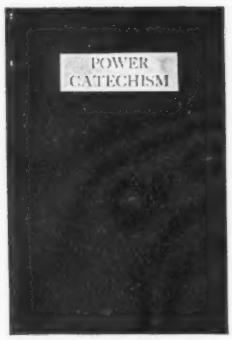
Climax Smoke Preventer Co., Boston, Mass.

Specialties, Power Plant

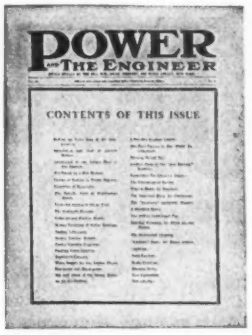
American District Steam Co., Lockport, N. Y.
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Baragwanath & Son, Wm., Chicago, Ill.
Berry Engineering Co., Chester, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Ia.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Lunkenheimer Co., Cincinnati, Ohio.

Look at This Special Offer!

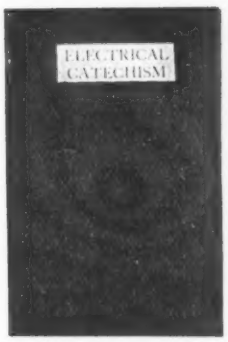
Regular Price, $6.00. To You, $3.50



Size 6x9. Price $2.00



Size 9x12. Price $2.00 a year



Size 6x9. Price $2.00

THE price of *Power and The Engineer* is $2.00 a year—straight. Power Catechism and Electrical Catechism are $2.00 apiece. You may have all three for $3.50. (To cover extra postage on paper, Canadian subscribers must add $1.00 to this offer. Foreign subscribers add $2.00.)

These two splendid books cover the field of steam and electrical engineering in the "question and answer" form. When you want a straight-out answer to a straight-out question you'll find it in one of these books. Power Catechism has 255 pages, profusely illustrated, size 6x9, with 750 questions and answers. Electrical Catechism has 210 pages, illustrated, 6x9, with 533 questions and answers. Both are bound in cloth.

Under this offer these books, regularly $2.00 each, will cost you 75c each!

If you're already a subscriber, renew *at once* no matter when your subscription expires. If possible, get a *new* subscriber, too. If you're not a subscriber, get in line NOW.

Offer limited. Today is the day to accept.

Power and The Engineer, 505 Pearl St., N. Y.

Old Subscribers Renew on This Blank

POWER AND THE ENGINEER,
505 Pearl Street, New York

Enclosed find . . . . . Renew my subscription for one year, *dating the renewal from the expiration of my present subscription*, and send me Power Catechism and Electrical Catechism.

Name .....

Address .....

Non-Subscribers Use This Blank

POWER AND THE ENGINEER,
505 Pearl Street, New York.

Enclosed find $ . . . . . for which send me the paper for one year together with Power Catechism and Electrical Catechism as per your special offer.

Name .....

Address .....

Specialties, Power Plant —*Continued.*
Ohio Brass Co., Mansfield, Ohio.
Patterson & Co., F. L., New York.
Penberthy Injector Co., Detroit, Mich.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Powell Co., Wm., Cincinnati, Ohio.
Reliance Gauge Column Co., Cleveland, O.
Restein Co., Clement, Philadelphia, Pa.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Robertson & Sons, Jas. L., New York.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Stephenson Mfg. Co., Albany, N. Y.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.
Webster & Co., Warren, Camden, N. J.

Stocks and Dies
Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, O.

Stokers
Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Westinghouse Mach. Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Pa.

Stokers, Mechanical
McClave-Brooks Co., Scranton, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Conn.

Strainers
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Foster Engineering Co., Newark, N. J.
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.

Superheaters, Steam
Babcock & Wilcox Co., New York.
Parker Boiler Co., Phila., Pa.
Power Specialty Co., New York.
Providence Eng. Wks., Providence, R. I.
Whitlock Coil Pipe Co., Hartford, Conn.

Supplies, Electrical
General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Ohio Brass Co., Mansfield, Ohio.

Supplies, Engineers'
Mound Tool & Scraper Co., St. Louis, Mo.

Supplies, Steam Heating
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Erie Mfg. & Supply Co., Erie, Pa.
Foster Engineering Co., Newark, N. J.
Ohio Blower Co., Cleveland, O.
Ohio Brass Co., Mansfield, Ohio.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Switchboards
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Switches, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Syphons, Acid
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Tachometers
Schuchardt & Schutte, New York

Tanks
Phoenix Iron Works, Meadville, Pa.

Taps and Dies
Toledo Pipe Threading Mach. Co., Toledo, Ohio.

Thermometers
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Tools, Scraping
Mound Tool & Scraper Co., St. Louis, Mo.

Track, Overhead
Yale & Towne Mfg. Co., New York.

Transformers and Converters
Crocker-Wheeler Co., Ampere, N. J
General Elec. Co., Schenectady, N.Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Transmission, Power
Jeffrey Mfg. Co., Columbus, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Reeves Pulley Co., Columbus, Ind
Saginaw Mfg. Co., Saginaw, Mich.

Traps
Anchor Packing Co., Philadelphia, Pa.
Anderson Co., V. D., Cleveland, O.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Houghton & Co., E. F., Philadelphia, Pa.
Jenkins Bros., New York.
Kitts Mfg. Co., Oswego, N. Y.
McCrea & Co., James, Chicago, Ill.
Morehead Mfg. Co., Detroit, Mich.
Ohio Blower Co., Cleveland, O.
Platt & Co., John, New York.
Reliance Gauge Column Co., Cleveland, O.
Schutte & Koerting Co., Phila., Pa.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.
Williams Valve Co., D. T., Cincinnati, O.

Trucks, Storage Battery Auto-
Westinghouse Machine Co., Pittsburg, Pa.

Tube Cutters
Lagonda Mfg. Co., Springfield, O.

Tubing
Ball & Wood Co., Elizabethport, N. J.
Johns-Manville Co., H. W., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Scully Steel & Iron Co., Chicago, Ill.

Turbines, Steam
Ball & Wood Co., Elizabethport, N. J.
De Laval Turbine Co., Trenton, N. J.
General Electric Co., Schenectady, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.

Unions
Lunkenheimer Co., Cincinnati, Ohio.
Pittsburgh Valve and Fittings Co., Barberton, O.
Williams Valve Co., D. T., Cincinnati, O.

Valves
Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
Foster Engineering Co., Newark, N. J.
Jenkins Bros., New York.
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Valve & Fittings Co., Barberton, O.

Valves—*Continued.*
Pittsburgh Valve, Foundry & Construction, Co. Pittsburg, Pa.
Schutte & Koerting Co., Philadelphia, Pa.
Walch & Wyeth, Chicago, Ill.
Watson & McDaniel Co., Philadelphia, Pa.

Valves, Ammonia
York Mfg. Co., York, Pa.

Valves, Automatic Cut-off
Lagonda Manufacturing Co., Springfield, O.
Walch & Wyeth, Chicago, Ill.

Valves, Automatic Relief
Walch & Wyeth, Chicago, Ill.

Valves, Back Pressure
Best Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Foster Engineering Co., Newark, N. J.
Jenkins Bros., New York.
Pittsburgh Valve, Foundry and Construction Co., Barberton, O.
Walch & Wyeth, Chicago, Ill.

Valves, Blow-off
Homestead Valve Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

Valves, Check
Walch & Wyeth, Chicago, Ill.

Valves, Cylinder Relief
Amer. Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.

Valves, Drain
Lunkenheimer Co., Cincinnati, O.
Powell Co., Wm., Cincinnati, Ohio.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Exhaust Relief
Walch & Wyeth, Chicago, Ill.

Valves, Float
Foster Engineering Co., Newark, N. J.
Homestead Valve Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Free Exhaust
Schutte & Koerting Co., Philadelphia, Pa.

Valves, Gate
Lunkenheimer Co., Cincinnati, O.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Pittsburgh Valve and Fittings Co., Barberton, O.
Powell Co., Wm., Cincinnati, Ohio.
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, O.

Valves, Hydraulic
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Powell Co., Wm., Cincinnati, Ohio.
Watson-Stillman Co., New York.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Iron Stop
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Lever and Throttle
Powell Co., Wm., Cincinnati, Ohio.

Valves, Non-return
Walch & Wyeth, Chicago, Ill.

Valves, Pop Safety
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, O.

Valves, Pump
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.

Valves, Reducing
Davis Regulator Co., G. M., Chicago, Ill.
Mason Regulator Co., Boston, Mass.
Ohio Brass Co., Mansfield, Ohio.
Watson & McDaniel Co., Philadelphia, Pa.

Valves, Regrinding
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Valve and Fittings Co., Barberton, O.
Powell Co., Wm., Cincinnati, Ohio.
Strong, Carlisle & Hammond Co., Cleveland, O.
Williams Valve Co., D. T., Cincinnati, O.

Valves, Regulating
Fisher Governor Co., Marshalltown, Iowa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Relief
Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
d'Este Co., Julian, Boston, Mass.
Jenkins Bros., New York.
Lunkenheimer Co., Cincinnati, O.
Peerless Rubber Mfg. Co., New York.
Power Specialty Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Wheeler Condenser & Engineering Co., New York.

Valves, Safety
Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Safety Gate
Walch & Wyeth, Chicago, Ill.

Valves, Stop Check
Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Swing Gate
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Water Relief
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.

Ventilators
Burt Mfg. Co., Akron, O.
Ohio Blower Co., Cleveland, Ohio.

Vises
Armstrong Mfg. Co., Bridgeport, Conn.

Water Columns
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Reliance Gauge Column Co., Cleveland, O.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

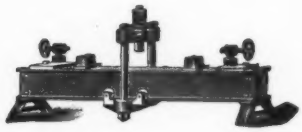
Whistles
Williams Valve Co., D. T., Cincinnati, Ohio.

Whistles, Chime
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Winches
Yale & Towne Mfg. Co., New York.

Wrenches
Curtis & Curtis Co., Bridgeport, Conn.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Wrenches, Pipe
Armstrong Mfg. Co., Bridgeport, Conn.
Trimont Mfg. Co., Roxbury, Mass.



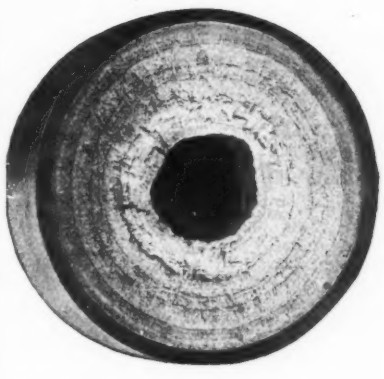
HYDRAULIC STRAIGHTENERS

WE have many patterns covering Hydraulic Shaft Straighteners both portable and stationary. These machines are capable of bending shafting or axles from 3½" diameter to 6" in diameter. One type of shaft straightener is made for fitting the Vs of the lathes.

SEND FOR CATALOGUE.

WATSON-STILLMAN CO.,
50 CHURCH STREET,
NEW YORK CITY.

DON'T RUN THIS RISK.



It's just what happens if you depend upon scale removal instead of scale prevention. Such scale wastes coal, is dangerous, and means shut downs and hard work at cleaning time.

It's better to *prevent* scale time by using

BIRD-ARCHER COMPOUNDS

and let us take the risk. Try them for six months. If they don't dissolve the old scale into sludge that can be blown out, if they don't prevent new scale, and if they don't do their work without injury to boiler, fittings, packing or cylinder lubricants, we will refund every cent paid.

Ask for book, "Boiler Troubles and Their Prevention."

BIRD-ARCHER COMPANY,
90 West Street, 16 **New York.**

Face to Face With Opportunity

Few of us have sufficient judgment at the outset of our careers to select the **trade** or profession for which we are best suited.

If you are **misplaced,** the sooner you are **displaced,** the better.

To-day you are **face to face with an opportunity** to advance—a chance to become just what you have been waiting to be. Your help, guide and instructor will be the **New Six Volume Edition**

CYCLOPEDIA *of* APPLIED ELECTRICITY

The information contained in the 3,000 7x10 inch pages will be found of the utmost value to the man who is face to face with **"Opportunity"** and wishes to grasp it. The 2,000 illustrations, diagrams, tables and formulas greatly increase the value of the books as a Home Study Instructor. The books are handsomely bound in half red morocco and are carefully indexed for ready reference—supplemented with a series of practical test questions.

All types of electrical appliances are given special attention, and every subject treated by a practical, technical expert—written plainly and clearly. The chapters on Theory, Calculation, Design and Construction of Generators and Motors; Electro-pneumatic control of Electric Railways; Single-phase Electric Railway, are especially complete and are well worth the cost of the entire set to the wide-awake **Electrical Engineer.** The ambitious **student** or **electrical worker** who is desirous of becoming thoroughly familiar with all details of Applied Electricity can find no better means for doing so than through a close study of this Cyclopedia.

This Cyclopedia was compiled from the representative instruction papers of the American School of Correspondence, and to acquaint the public with the superiority of the School's Home Study Courses, we make this special

FREE FIVE-DAY OFFER

We will send you, express prepaid, a set of these beautiful books absolutely Free for five days' examination, on receipt of Coupon. If the books are satisfactory and you wish to keep them, send us $2.00 within five days and $2.00 a month until you have paid the special $18.60 price; otherwise notify us and hold the books subject to our order. It will cost you nothing to examine the books—we employ no agents.

SPECIAL PRICE $18.60--REGULAR PRICE $36.00

Order promptly and we will include FREE for one year as a monthly supplement, the

TECHNICAL WORLD MAGAZINE

A popular magazine with a technical turn containing the latest discussion on timely topics in Science, Invention, Discovery and Industry, also the best Fiction, Biography, Travel and Humor, in fact, the best of everything. Illustrated with scores of interesting photographs.

BRIEF LIST OF CONTENTS

Management of Dynamos and Motors, including the Location and Remedy of Troubles, such as Sparking at the Commutator, Heating, Etc.; Power Stations; Central Station Engineering; Central Station Design; Power Transmission; Alternating Current Generator; Synchronous Motor, Induction Motor, Transformer, Rotary Converter, Frequency Changer, Etc., Theory, Calculation, Design and Construction of Generators and Motors; Types of Dynamo and Motors; Elevators; Direct Current Motors; Electrical Measurements; Electric Lighting, including Arc and Incandescent Lighting, Nernst Lamp, Cooper-Hewitt Lamp, Osmium Lamp, Etc.; Electric Railways including Third Rail System, Multiple Unit Control, Electro-Pneumatic Control; Alternating Current Motors, Etc.; Single-Phase Electric Railway; Electric Welding; Mercury Vapor Converter; Storage Batteries, including Charging and Discharging Troubles and Their Remedies, Tests for Impurities, Etc.; Electric Wiring; Electric Telegraph; Wireless Telegraphy; The Telautograph; Telephony, includes Instruments, Lines, Exchanges, Common Battery Systems, Operation, Maintenance; Automatic Telephone; Wireless Telephony; Telegraphone, Etc.

American School of Correspondence

CHICAGO, U. S. A.

FREE OFFER COUPON

Fill In, Clip and Mail Today

American School of Correspondence:

Please send Cyclopedia of Applied Electricity for FREE examination; also T. W. for 1 year. I will send $2.00 within five days and $2.00 a month until I have paid $18.60, otherwise I will notify you and hold the books subject to your order. Title not to pass until fully paid.

Name.....

Address.....

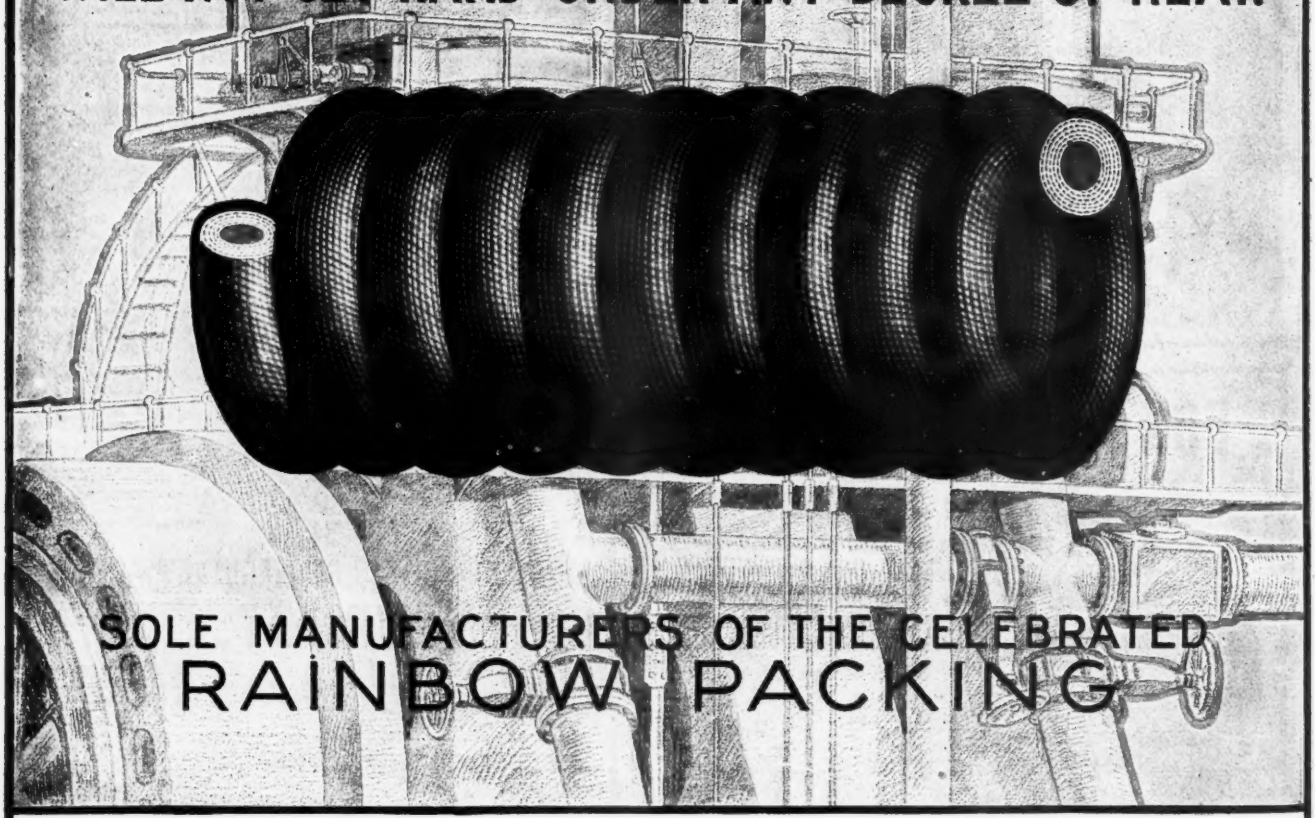
Occupation.....

Employer.....

Power, 11-10-08.

PEERLESS SPIRAL PISTON AND VALVE ROD PACKING

IS THE MOST SATISFACTORY PACKING IN THE WORLD.
IT WILL RUN FROM 12 TO 16 MONTHS WITHOUT REPACKING.
WILL HOLD 400 POUNDS OF STEAM.
IT WILL PACK TIGHTLY ANY ROD HOWEVER BADLY SCORED AND CORRODED.
WILL NOT GET HARD UNDER ANY DEGREE OF HEAT.



SOLE MANUFACTURERS OF THE CELEBRATED
RAINBOW PACKING

PATENTED MANUFACTURED EXCLUSIVELY BY

THE PEERLESS RUBBER MANUFACTURING COMPANY

16 WARREN ST., NEW YORK

DETROIT, MICH.-16-24 WOODWARD AVE.
CHICAGO, ILL.-202-210 SO. WATER ST.
PITTSBURG, PA.-425-427 FIRST AVE.
SAN FRANCISCO, CAL. 131 153 KANSAS ST.
NEW ORLEANS, LA. COR. COMMON & TCHOUPITOULAS STS.
ATLANTA GA.-7-9 SOUTH BROAD ST.
KANSAS CITY, MO.-1221-1223 UNION AVE.

SEATTLE, WASH-RAILROADWAY & OCCIDENTAL AVE.
LOUISEVILLE, KY-111-121 W. MAIN ST.
INDIANAPOLIS, IND-16-18 SQ. CAPITOL AVE
OMAHA, NEB.-12 18 FARNAM ST.
DENVER, COL.-1723-1731 BLAKE ST.
RICHMOND, VA.-COR. NINTH & CAREY STS.
WACO, TEXAS-709-711-AUSTIN AVE.

BOSTON, MASS.-110 FEDERAL ST.
BUFFALO, 379-383 WASHINGTON ST.
MILWAUKEE, WIS. 96-100 SECOND ST.
SYRACUSE, N.Y.-212-214 SO. CLINTON ST.
LOS ANGELES, CAL-115 SO. LOS ANGELES ST.
PORTLAND, ORE.-14-16 FIRST ST.
BALTIMORE, MD.-37 HOPKINS PLACE.

FOREIGN DEPOTS

LONDON E.C., ENGLAND.-58 HOLBORN VIADUCT
PARIS FRANCE.-76 AVE DE LA REPUBLIQUE.
SYDNEY, AUSTRALIA.-270 GEORGE ST.
JOHANNESBURG, SOUTH AFRICA.-2427 MERCANTILE BL'D'G
COPENHAGEN, DEN.-FREDERIKSHOLMS KANAL 6.
VANCOUVER, B.C.-CARRAL & ALEXANDER STS.

ENGINEERS WHO HAVE USED

INDIAN RED SHEET PACKING

Will tell you it has the

STAYING AND RESISTING QUALITIES

It is efficient in every respect
which, in the end, means economy.

A 14 x 28 hanger, like cut herewith, but in colors,
free to any engineer upon request.

The DIAMOND RUBBER CO., AKRON, OHIO.

Complete Diamond Stocks Carried By

The Diamond Rubber Co. of N. Y.,
1876 Broadway, N. Y.

The Diamond Rubber Co.,
1523 Michigan Ave., Chicago, Ill.

The Diamond Rubber Co.,
Mission and 2nd Sts., San Francisco, Cal.

Buffalo Mill Supply Co.,
Buffalo, N. Y.

Southern Hardware & Supply Co.,
Mobile, Ala.

Consumers Rubber Co.,
Cleveland, Ohio.

The Diamond Rubber Co. of N. Y.,
304 N. Broad St., Philadelphia, Pa.

The Diamond Rubber Co.,
3963 Olive St., St. Louis, Mo.

The Gustin-Bacon Manufacturing Co.,
Kansas City, Mo.

Pittsburgh Rubber & Leather Co.,
Pittsburgh, Pa.

Alabama Machinery & Supply Co.,
Montgomery, Ala.

M. I. Wilcox Co.,
Toledo, Ohio.

VANDA

A STEAM PACKING THAT IS A STEAM PACKING

TRADE MARK. REG. IN U. S. PAT. OFF.

All Goods Stamped with the VANDA TRADE-MARK will fulfill the claims we make for them.

VANDA SHEET PACKING

THIS PACKING IS THE PIONEER OF ALL COMPOSITION PACKINGS, AND IMITATORS ARE APPEARING IN GREAT NUMBERS. WE THEREFORE, WOULD ESPECIALLY CALL YOUR ATTENTION TO OUR

TRADE-MARK DEVICE STAMPED ON EVERY SHEET

GOODS MADE IN SHEETS ONLY OF 4½' x 4½' AND 4½' x 9', IN ALL THICKNESSES

THE VANDA COMPANY, 96 SPRING STREET, N. Y.

H. W. JOHNS-MANVILLE CO., CO-DISTRIBUTORS

Cobb's High Pressure Spiral Piston Rod and Valve Stem Packing

Cobb's Throttle Packing

Cobb's High Pressure Ring Packing

Graphon Spiral Packing

THESE illustrations show a few of our standard, high grade, Spiral, Ring and Sheet Packings, which we manufacture for use in Locomotives, Steamships, Paper Mills, Saw Mills, Mines and Mill Engines of all kinds.

We have doubled the capacity of our Packing Department, at the Factory and are equipped to make Packings to meet any condition at short notice. Write for samples and Engineers' Catalogue, showing our full line.

Magic Diagonal

Branches

CHICAGO, ILL.
150 Lake St.
ST. LOUIS, MO.
218-220 Chestnut St.
PHILADELPHIA, PA.
118-120 North 8th St.
SAN FRANCISCO, CAL
East 11th St. and
3d Ave., Oakland

NEW YORK BELTING & PACKING COMPANY, LTD.

91-93 CHAMBERS STREET, NEW YORK

Branches

BOSTON MASS.
232 Summer St.
BALTIMORE, MD.
114 W. Baltimore St.
BUFFALO, N. Y.
600 Prudential Bldg.
PITTSBURGH, PA.
913-915 Liberty Ave.
SPOKANE, WASH.
163 S. Lincoln St.

Indestructible White Sheet Packing

Karbonite Black Sheet Packing

Ruby Red Sheet Packing

"Blood is thicker than water"—but not nearly as thick as the man who refuses to try a good packing simply because he has been dubbing along for years with some inferior brand.

There's all the difference in the world in packings—the high grade kind save unlimited time, trouble and expense; the others are wasteful, troublesome and unsatisfactory.

That's why it pays every Engineer to take a little time in experimenting, in trying and comparing packings. And that's where *Genuine* EUREKA shines. Give it a fair trial and you'll see how it gives perfect service on worn or scored rods, how it outlasts others, how it creates minimum friction—and this at one-third the cost of other good makes.

We also make Cut Ring, High Pressure, Water Proof Hydraulic, in rings and coils, Spiral and Red Sheet Packings.

Ask for Samples and Prices.

Eureka Packing Co.

Jas. L. Robertson, President

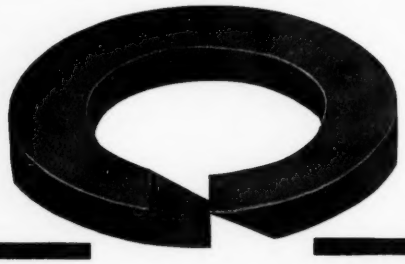
Sales Department: 46 Warren St., New York

Isn't it worth money to you to know exactly what power your engine is developing? Don't you see how it will allow you to get results that will mean promotion?

The Robertson-Thompson Indicator and Victor Reducing Wheel make an outfit that furnishes just the information you want. Price is moderate—one-third less than others—and easy terms are offered if desired. Details?

Jas. L. Robertson & Sons,

46 Warren Street, New York



GOOD MATERIAL GOOD PACKING

BEST MATERIAL BEST PACKING

Johnson's Packings are best, because they're made of the **best stuff** in the **best manner.** They are always open to investigation and have nothing to hide.

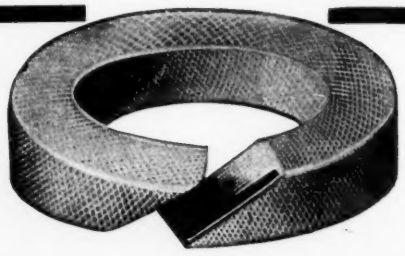
When a packing that's made of just "merely good" material tries to **make up** on some "fool secret compound, or process"—**look out!**

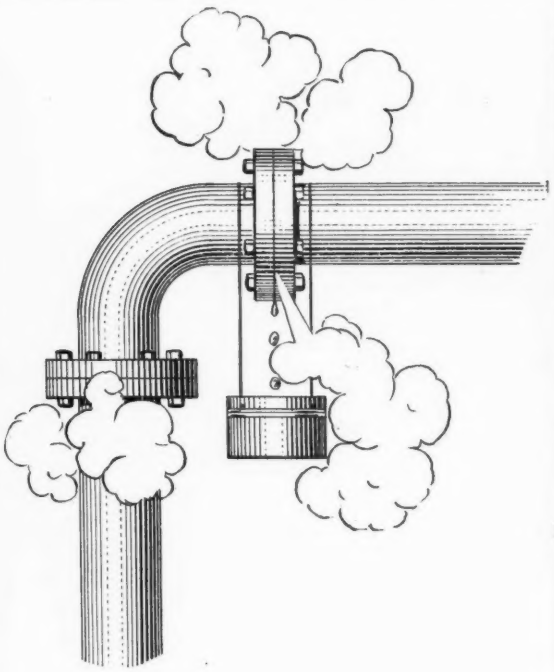
Our packings are made for all purposes by workmen who are **trained** in packing manufacture.

WRITE FOR CATALOG.

THE HENRY JOHNSON COMPANY,

JERSEY CITY, NEW JERSEY.

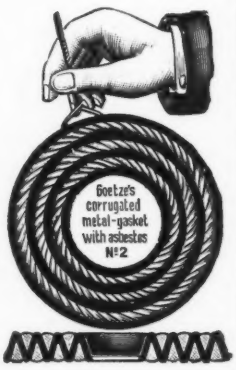




THIS WOULD NEVER HAVE HAPPENED

had the joints been made tight in the first place by **Goetze's Elastic Copper Gaskets.**

It's no use worrying over lost steam, however. The thing to do is to fix the leaky joints so that *no more* steam will escape. And the only positive way to go about it, is to introduce Goetze's Gaskets.



No matter how high the pressure or temperature--Goetze's Copper Gaskets "will do the trick." Write for free sample and details.

American Goetze-Gasket and Packing Co.,

525 East 149th St., NEW YORK.

BELMONT "HYDRAULIC"

Style No. 8

is stitched through and through crossways; it can't swell, can't pinch, can't be twisted apart, can't do anything in fact, except stay right where it's put and keep the pump absolutely water tight with the least possible friction. Observe its construction—First, a core of finest braided flax, soft and tough.

Around three sides of this a casing built up of alternate layers of the best rubber and cotton duck, with the edges turned toward the rod, thereby insuring great durability. Then the cross stitching as described. Could anything be better? We think not, and the testimony of engineers who use Belmont Hydraulic No. 8 is that it's as near perfection as anything gets to be in this world below.

For every kind of pumping service and hydraulic machinery, and especially valuable when exposed to alkaline or sulphuric acid mine waters. Write for booklet C.

FREE Send for sample ring and be convinced. **FREE**

CLEMENT RESTEIN CO., Philadelphia, Pa.

Gentlemen:—Send me a sample ring of Belmont Hydraulic Packing, Style No. 8.

Name.....
Address: St. No.....City.....State.....
Firm Name.....
Number of Engines.....
Number of Pumps.....
Number of Boilers.....
High or Low Pressure.....
Packing now in use.....

Power, Nov. '08.

CLEMENT RESTEIN CO.,
133 N. Second St., Philadelphia, Pa.
Mfgrs. of every variety of packing and gaskets. General catalog on request.

Salesmen Wanted

To call at power plants, pumping stations and engine rooms and sell BELMONT PACKINGS and Specialties. Particularly attractive proposition for manufacturers, agents and engineers in territory not already covered.

CLEMENT RESTEIN CO., 133 N. Second St., Philadelphia, Pa.

THE strength of leather is directly proportionate to the length of its fibres. The illustration shows a piece of VIM and one of Oak Leather broken under the same conditions. The superior length of the fibres of VIM are plainly shown.

This is one of the many reasons why

LEATHER TRADE VIM MARK PACKINGS

can be guaranteed to wear twice as long as any other. They do not break and wear because the fibres are so long they hold together.

If you will send us measurements of your packings, we will make you up a sample packing and sell it to you with the absolute guarantee that it will last you twice as long as that which you are using.

E. F. HOUGHTON & CO.,

240-250 W. Somerset Street, Philadelphia

175-177 Lake Street, Chicago
98-110 Bates Street, Detroit
109 Liberty Street, New York
96 Cornhill, Boston

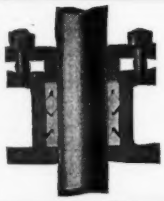
Look at the Cut

and you will see how simply and effectively the

Gardner Exhaust Heads

provide against back pressure and provide for extracting every bit of oil and condensation by force of gravity. Write.

The Gardner Governor & Separator Co.
Quincy, Illinois.



VERY SIMPLE

To apply LAW Improved Metallic Packing, it is not necessary to have special stuffing boxes or to alter existing ones. No springs are used. Write for circular.

HOUCHIN-AIKEN COMPANY,
Sole Manufacturers.
113-121 Fifty-Third St., Brooklyn, N. Y.

Try N. I. R. Red Sheet

and know why successful engineers are using it.

NATIONAL INDIA RUBBER COMPANY,
FACTORY, BRISTOL, R. I.
BRANCHES: 42 Broadway, New York. 84 Lake St., Chicago.
140 Essex St, Boston. 37 Hopkins Pl., Baltimore.
379 Washington St., Buffalo.

BLACK SQUADRON

(The 4 Wedge Packing)

Can be used on rods, where no other packing will give satisfactory results. That's because the 4 wedge design enables it to respond perfectly to every irregularity of the rod or stem. Materials of highest quality throughout; every particle lubricated, keeps rods in perfect condition. *Illustrated catalog on request.*

CANCOS MFG. CO.
Philadelphia, Pa.
10 Oliver St., Boston, Mass. 525 Third Ave, Pittsburg, Pa.
305 Plowman St., Baltimore, Md.

See FREE OFFER of

AMBEST PACKING

Oct. 27th issue of "Power and Engineer"

CANFIELD MFG. CO., Philadelphia

"THURIL"

The Famous Sheet Packing, Made for Severe Duty.
No Test Too Hard. Write for Particulars.

THE ANCHOR PACKING COMPANY,
Main Office and Factory:
Allegheny, Sedgeley and Germantown Aves., PHILADELPHIA, PA.

"SAFETY" PLASTIC METALLIC PACKING

For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc.

Guaranteed to stand Steam Temperature up to 550° F. and Hydraulic Pressure to 5000 lbs. per sq. inch.

Highest Award World's Fair, St. Louis.

Send for FREE SAMPLE and particulars.

MANUFACTURED BY
STEEL MILL PACKING CO., Detroit, Mich., U.S.A.

"SAYEN-REED"

SAYEN-REED ASBESTOS PACKING

Specially Adapted for High Pressure and Super-heated Steam—The fabric is woven from strands made of brass wire and asbestos. Rubber is then forced in the interstices and vulcanized. The result is a remarkably strong, flexible and durable packing which no pressure will blow out.

Write for Free Sample

This packing is better than others—far better—and, better still, is lower priced. We will gladly send samples FREE upon request.

MERCER RUBBER COMPANY
HAMILTON SQUARE NEW JERSEY

BRANCH OFFICES—Philadelphia, 421 Arcade Bldg.; New York, 250 Fulton St.; Pittsburg, Pittsburg Rubber Supply Co., 8th and Liberty Sts.; Denver, Foster & Taylor, 610 Exchange Bldg.; and Chicago, 40 Dearborn St.

TRIMO PIPE CUTTER

(TRADE MARK)

Combination 1 and 3 Wheel.

NOT THE CHEAPEST, BUT THE BEST.

Only a trial needed to demonstrate its superior qualities. Drop forged steel frame. Rolls keep cutter straight and remove burrs from pipe. All parts interchangeable and guaranteed. Send for our Catalogue No. 21.

TRIMONT MANUFACTURING COMPANY, 55-71 Amory Street, Roxbury, Mass.

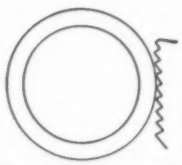
NO. 1

FOR PIPE— **FOR FITTINGS**

"Agrippa"

Just Show Yourself—Never Mind Missouri,

Take a cardboard mailing tube and principle No. 1; the push or pull is in a line tangent with the circle of the pipe—non-crushing. Take the principle No. 2 (broad jaw tools) straight push and crush. What will save the old rusty pipe? Old principles and perfect tools like ever useful, ever reliable "Old Agrippas." Discount and trial from your dealer.



No. 2 Principle.

J. H. Williams & Co., Pioneers in Chain Pipe Tools. **Brooklyn, New York.**

Carey's 85 per cent Carbonate Magnesia Coverings

THE largest contract ever awarded for steam pipe and boiler coverings specified Carey's. This was the result of an exhaustive test conducted by the Manhattan Railway Company of New York, which proved Carey's Coverings to be more efficient and far superior in every way to any other of the numerous makes. No other coverings proved to be as light, clean and substantial.

Carey's Coverings are absolutely fire-proof, and being thorough non-conductors of heat they confine the heat to the pipes, effectually preventing its loss through radiation, thus saving in fuel an amount sufficient to *more* than offset the cost of their application.

The most prominent steam users everywhere use Carey's Covering. Do you want to know why?

Send for Carey's Magnesia Catalogue. It gives information not obtainable elsewhere.

THE PHILIP CAREY COMPANY

General Offices: Station R, Cincinnati, O.

FACTORIES: Lockland, Ohio; Plymouth Meeting, Pa.

Branches and Warerooms:

New York: 114-118 Liberty Street.
St. Louis: 908 North 2nd Street.
Baltimore, Md: 332-334 North Street.
Philadelphia, Pa.: 12th and Buttonwood Sts.
Toronto, Canada: 112 Bay Street, East.
Cleveland, Ohio: 123 Water Street.
Buffalo, N. Y.: 45 Pearl Street.
Pittsburg, Pa.: 333-335 Second Avenue.
Atlanta, Ga: 34 West Alabama Street.
Charlotte, N. C.: East 7th and R. R. Streets.
New Orleans, La.: 222 Chartres Street.

One of the biggest problems you go up against

is tracing, locating and correcting motor troubles. The biggest help that has ever been devised to relieve you of the burden of motor troubles is

MOTOR TROUBLES

It is a book written by the most eminent authority in this country, E. B. Raymond, head of the testing department of the General Electric Company. In it Mr. Raymond tells you what he knows about the best and quickest ways of tracing, locating and correcting direct- and alternating-current motor troubles and the testing of direct- and alternating-current machinery. When you've got Raymond's knowledge of these subjects within reach, you've got a sure way of saving your good money, time and temper.

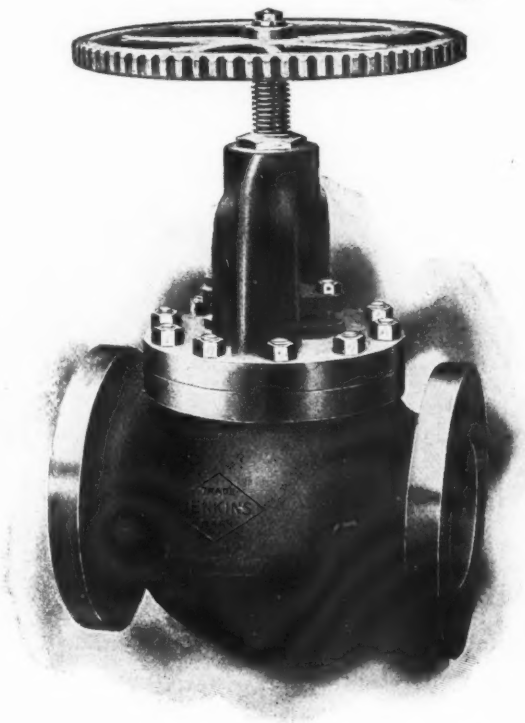
If you ever handle motors, of any kind or make, you'll find that the $1.50 invested in this book is pretty close to the best $1.50 you ever paid out. And, besides, if you'll send us the price of the book we'll ship it postpaid with a guarantee to refund your money if you return the book within 5 days of receipt. And that *goes!*

HILL PUBLISHING COMPANY,

505 PEARL STREET, NEW YORK.

Publishers of POWER AND THE ENGINEER

JENKINS BROS. EXTRA HEAVY GATE VALVES



THESE valves are of the double face, solid wedge type, with either inside screw, stationary spindle, or outside screw, and yoke, rising spindle.

The design effectually prevents chattering and uneven wear.

They are tested to 800 pounds hydraulic pressure and guaranteed **for working steam pressures up to 250 pounds.**

They are also particularly adapted to high pressures of water and air, special discs being supplied when valves are ordered for this service.

Write for our illustrated descriptive catalog.

JENKINS BROS.

71 John St., New York.

35 High St., Boston.

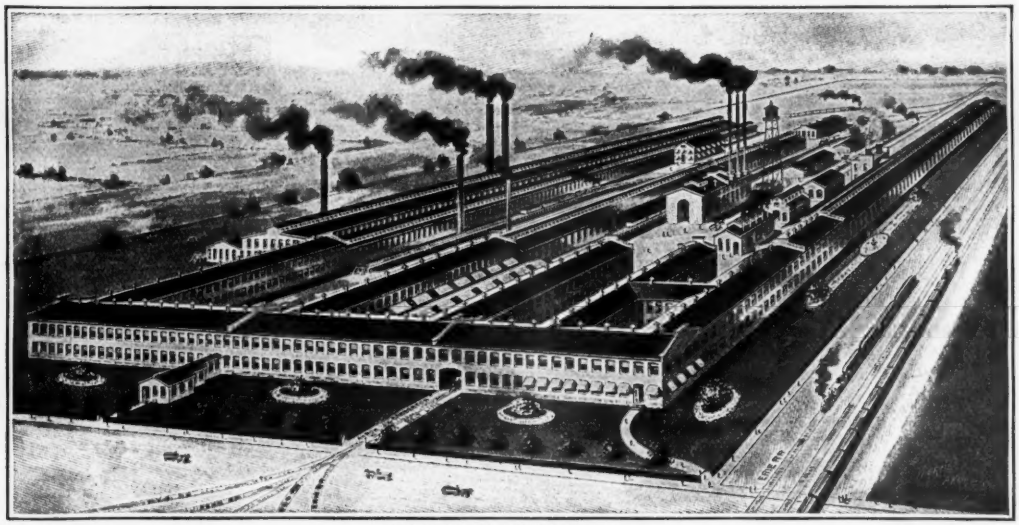
133 N. 7th St., Phila.

226-228 Lake St., Chicago.

ALWAYS SPECIFY **P** VALVES AND FITTINGS.

PITTSBURGH IRON BODY GATE VALVES

have been thoroughly tested under the most severe conditions known and have proved that they work under all pressures with less wear on the faces of the discs and seats than any other valves made.



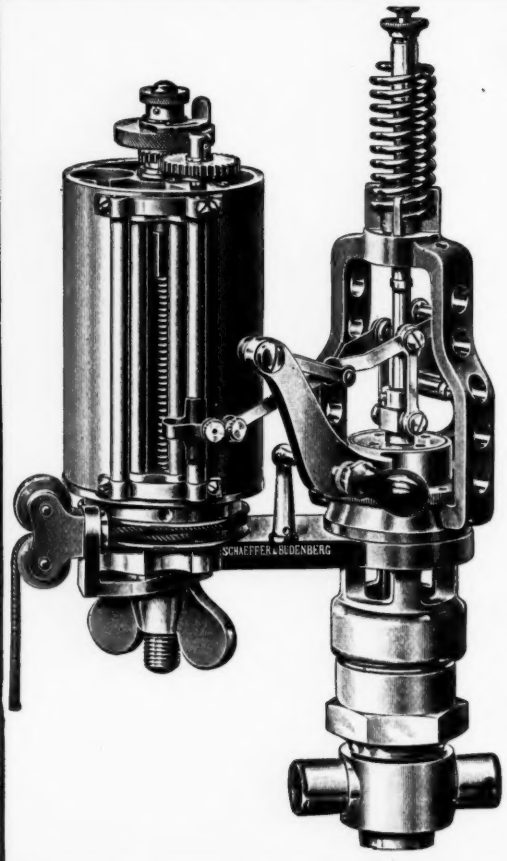
WORKS, BARBERTON, O.

They are made standard for 150 lbs. and extra heavy for 250 lbs. working pressures. They can be furnished screwed, flanged or hub end; with by-pass, spur or bevel gearing and are suitable for steam, gas or water. They are made with outside screw and yoke or non-rising spindles. We have many thousands of them in use in all parts of the country and have never had a complaint or a valve returned.

ALWAYS SPECIFY **P** VALVES AND FITTINGS.

PITTSBURGH VALVE & FITTINGS COMPANY,

General Offices and Works: BARBERTON, O. We Manufacture all kinds of Valves and Fittings.



THE S & B THOMPSON DIFFERS FROM OTHER INDICATORS

in that by taking a strip of paper six feet long and making 50 to 100 continuous indications, it enables you to read the average, rather than the momentary condition.

As reliability of information is the supreme test of indicator efficiency the above difference places the Thompson in a class by itself.

You will find a complete description in our new Indicator Catalogue. Write for a copy—FREE.

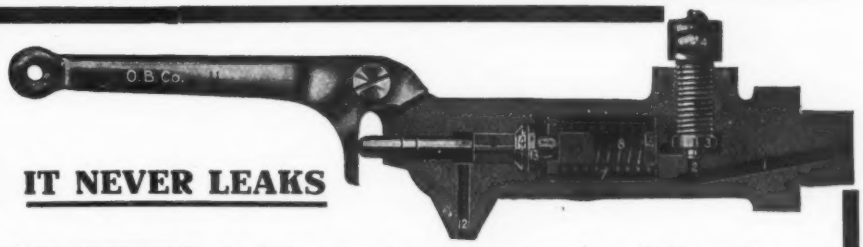
The

SCHAEFFER & BUDENBERG MFG. CO.

963-5 Kent Avenue, BROOKLYN, N. Y.

CHICAGO OFFICE, 15 West Lake Street.

COLLIN GAUGE COCK



IT NEVER LEAKS

IS ABSOLUTELY TIGHT UNDER ANY PRESSURE. In closing, the piston "13" enters the cylinder, cutting down the velocity of the fluid through the seat "14" and preventing steam-cutting as the valve closes. A slight movement of the lever reduces velocity of discharge and prevents flashing. Made of high grade steam bronze and with or without packless, non-sticking shut-off valve.

CATALOGUE "P-F," describes all our steam specialties, including Water Gauges and Heavy Bronze Fittings.

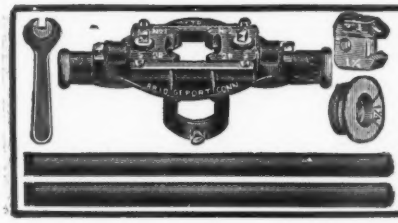
THE OHIO BRASS CO., MANSFIELD, OHIO, U. S. A.

New York, 32 Cortlandt St. Chicago, 277 Dearborn St. St. Louis, 10 North 4th St. San Francisco, 138 Front St.

HERE YOU ARE!

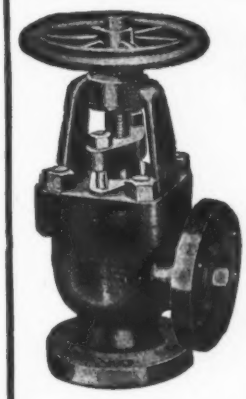
Just what you need to reduce those coal bills; the Mason Reducing Valve. It reduces and maintains air, steam or water pressure at any point, regardless of variations in initial pressure. Set and locked by key. Write for Catalog.

The Mason Regulator Co., Boston, Mass.



STOCKS AND DIES
PIPE MACHINES,
PIPE CUTTERS,
VISES.

Manufactured by
The Armstrong Mfg. Co.
287 Knowlton St.,
BRIDGEPORT, CONN.



Manufacturers of the

EDWARD VALVE

For High Pressures,
Superheated Steam and Water.

THE LAMMERT & MANN
Oil Dash Pots for Corliss Engines,
Gas and Gasoline Engines.

LAMMERT & MANN,
ENGINEERS and MACHINISTS,
157 S. Jefferson St. CHICAGO, ILL.

FOSTER VALVES

A visit to any steam plant employing Foster Valve Specialties; a little observation on your part of the various good points about them will readily convince you of their true worth.

We show here a Foster relief or free exhaust valve. This valve gives instant relief to the exhaust in case of the failure of the condenser or loss of vacuum.

It is sensitive, noiseless and has no parts liable to be clogged or corroded.

Write for Catalog

FOSTER ENGINEERING COMPANY,
NEWARK, N. J.

Room 423, No. 40 Dearborn St., Chicago, Ill.
403 Harrison Bldg., Philadelphia, Pa.
Stock carried at
Adkins, Young & Allen Co., 50 and 52 S. Canal St., Chicago, Ill.

PUT US TO A TEST!

Try us out! Make us prove that the valves and pipage equipment we make have **very few equals** and **positively no superiors!** We are anxious that you do! We have been making good valves so long, and have been pleasing the most expert and most critical mechanics in such a large part of the civilized world for so long, that we are absolutely sure of our position!

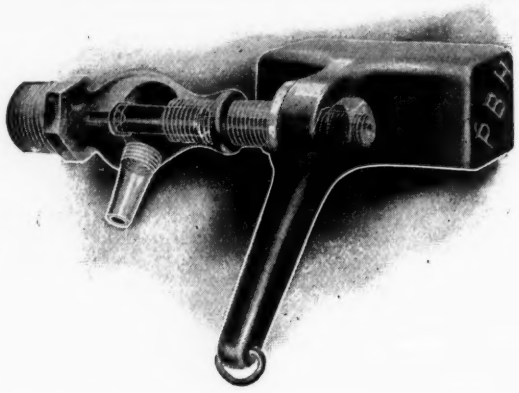
From the very smallest and plainest valve, up to the very largest and most intricate piece of pipage, we turn out clear on top of the very highest pitch of perfection.

Some few of them are: Tuyeres, Tuyere Cocks, Regulators, Traps, etc.

Send for Catalogue.

PITTSBURGH VALVE,
FOUNDRY AND CONSTRUCTION COMPANY

PITTSBURGH NEW YORK BOSTON
CLEVELAND BIRMINGHAM, ALA.

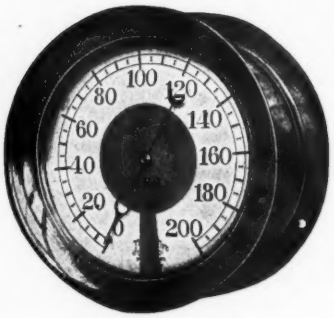


The Metal Pencil Lasts for Years

and then when it finally does wear out it can instantly be replaced at the trifling cost of a few cents. This valve pencil is the only wearing part about the **"P.B.H." Gauge Cock.** We guarantee the **"P.B.H."** leakless for years. Shipped to your plant on a 30 days' free trial. Write !

THE PAUL B. HUYETTE CO.
2025 BETZ BLDG., PHILADELPHIA, PA.

Worth Its Weight In Gold



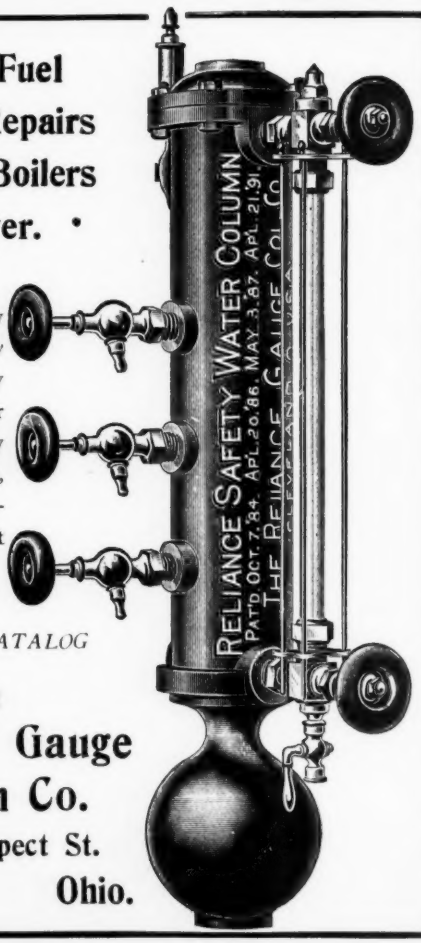
An accurate reliable steam gage will actually save its weight in gold, and more, by making possible economies which could never be attained without its help.

The Ashton is the most accurate and reliable gage that money can buy.

Catalog on Request

The Ashton Valve Co.
BOSTON NEW YORK CHICAGO
St. Johns House, London, E. C.

Saving of Fuel
Saving of Repairs
Saving of Boilers
Steady Power.



Reliance Safety Water Column *may* save your life by preventing a boiler explosion but they *will surely* save fuel, repairs and equipment and is not that enough?

ASK FOR CATALOG

The Reliance Gauge Column Co.
75 E. Prospect St.
Cleveland, Ohio.

The overload capacity of **G-W** electric generators makes them popular with the engineer. In emergencies they do better than is expected of them. Bulletin 80M describes our D. C. machines.

GROCKER-WHEELER COMPANY
Ampere, N. J.

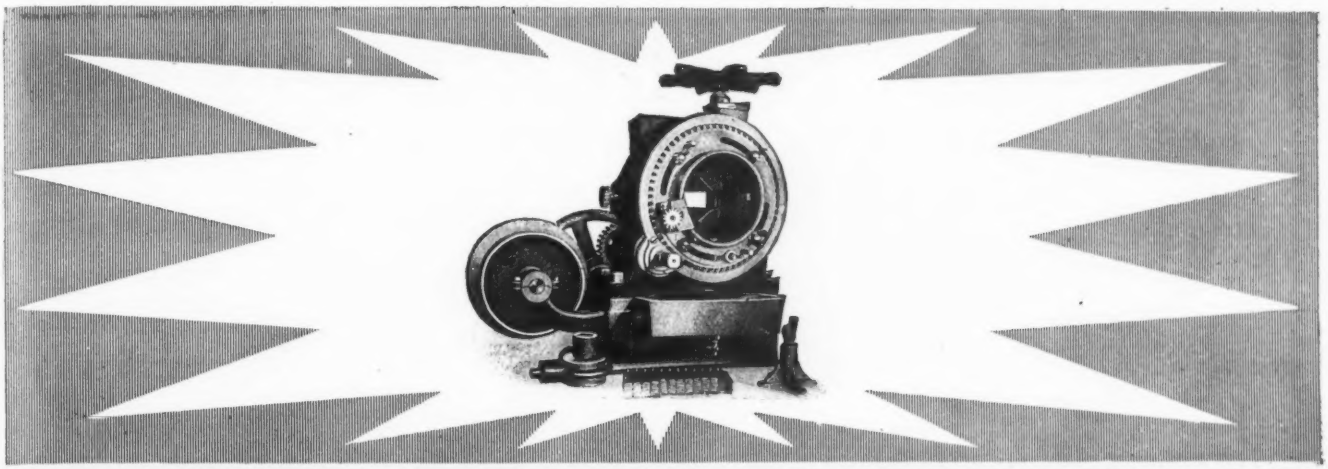
They become integral parts of the pipe, expanding and contracting with it. Made of the same grade metal.

"BALLWOOD" Welded Flanges

Everyone can now have permanently tight, leakless joints.

Circular 104 describes the best flanges made.

The BALL & WOOD CO.
ELIZABETHPORT, N. J.
New York Sales Office, Cortlandt Building, 30 Church Street
BUILDERS OF BALLWOOD ENGINES



The "Forbes"

For Over A Quarter Of A Century The Standard By Which All Other Machines Are Judged

Other machines have tried in vain to equal the high standard of excellence set by the Forbes Patent Die Stock. Their failure is due to lack of experience and inability to apply the Forbes EXCLUSIVE *money-making features.*

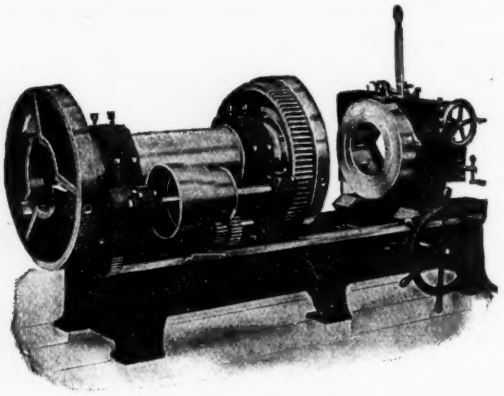
The "Forbes" is the only machine on the market with receding gear carrying the dies onto the pipe. It is also the only machine on which the shell can be adjusted to take up the wear of the gear, and the only machine with a device for protecting the gear from chips.

The "Forbes" is simple, compact, light, strong, durable, portable and accurate. Less power is required to operate it and there are fewer moving parts and *no unnecessary changes.* One man, operating a "Forbes" can secure *better results* than three or four men using the old-style stock and die. The Forbes will save you money on *first cost,* too.

Write for illustrated catalog.

The Curtis & Curtis Company,

85 Garden St., Bridgeport, Conn.



READ THIS!

"Foreman says that the machines cut the cleanest threads he has ever seen and while originally they have favored the installation of another make which they have been using for ten years, they now say they would not give the Bignall & Keeler for forty of the other make—the latter, too, is a very good machine."

Bignall & Keeler Mfg. Co.
Edwardsville, Ill.

More Dies for Less Money

Being provided with a set of dies for each size of pipe the

Toledo Pipe Threading Devices

give many times the die service of any other similar tools. The Toledo proves to be far less expensive when compared with the inferior devices for threading pipe. Write.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO, U. S. A.

The Average Union Sticks

"M. & F."

It rusts together. And what good is a union in the pipe line unless it can be disconnected? It's probably only good enough to throw away after you've forced it apart. **"KEWANEE" UNIONS** are made with a brass-to-iron thread connection and seal. Thus they can always be disconnected without the least trouble. WRITE!

National Tube Co., Pittsburgh, Pa.

DISTRICT SALES OFFICES

Atlanta	Denver	New York	Pittsburgh	St. Louis	Salt Lake City
Chicago	New Orleans	Philadelphia	Portland	San Francisco	Seattle

Every valve in your plant should be tested with a

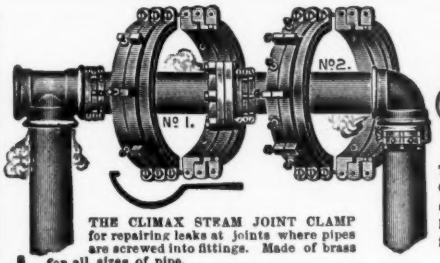
DEXTER Valve Reseating Machine

The operation is simple and effective. The jaws of the machine are quickly adjusted to the opening in the valve casing by rotating the scroll of the chuck. This centers the machine and the tool spindle that carries the cutter is in perfect alignment. A few turns and the seat is cut perfectly true. It cannot be otherwise. Any mechanic can do the job. The disc is recut by the same machine the same angle as the seat, making an accurate joint that will hold high pressure steam or water.

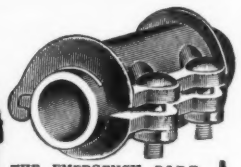
If you have concealed leaks, this operation will fix them.

Catalog P for asking.

THE LEAVITT MACHINE CO.
ORANGE, MASS., U. S. A.

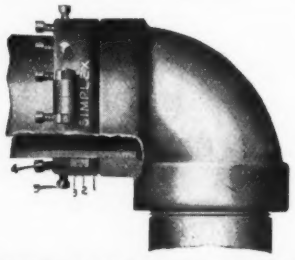


THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.


THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ½ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

Send for Catalog of
STEAM SPECIALTIES
JAMES McCREA & CO.,
MANUFACTURERS,
61 West Washington Street, Chicago.



THE WORST JOINT IN YOUR PLANT

can be made absolutely and permanently tight, provided you use the Simplex Pipe Clamp. Why allow your plant to bleed to death? WRITE!

THE SIMPLEX ENGINEERING CO.,
326 Preston Street, PHILADELPHIA, PA.

ARE YOUR CONDENSERS FREE FROM SCALE?

Weinland Direct Water Motor Driven Cleaner Operating in 1¼" Condenser Tubes.

How scale cuts down condenser efficiency and capacity may be judged from the experience of the Muncie Ice & Cold Storage Co., Muncie, Ind. Eight months after starting their ice plant, it took as long to make seventy cans of ice as it previously took to make a hundred. The 30% reduction in output was the direct result of scale in the ammonia condenser. When this scale was thoroughly removed by the

Weinland Mechanical Cleaner

the plant was at once restored to normal capacity. Mr. Clay Whiteley, President of the company, stated that the cleaning decreased coal consumption a ton a day and prevented further loss ot $20.00 worth of product per day.

The only way to clean condenser tubes is to bore or drill them out with the Weinland Mechanical Cleaner. The powerful steam, air or water motor won't "stall" in the hardest scale, but sends the cleaning head through it in a jiffy. As Prof. McCracken of Ohio State University says, after cleaning their condensers with this Weinland Machine, "We now do in a day what formerly required a week's time and the tubes are cleaner than by the old method of cleaning. We certainly are pleased with the machine."

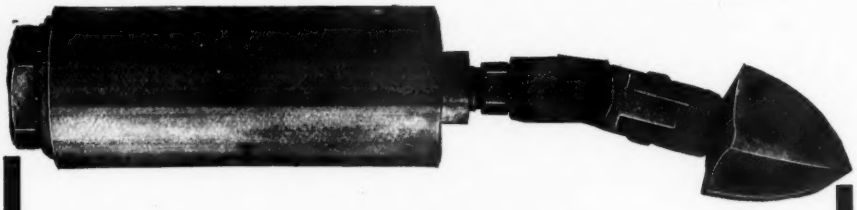
We send any Weinland Cleaner on trial, or will clean your boilers, condensers, economizers, etc., at a fixed price per tube, or per year.

Write for treatise, "Boiler Scale and Its Removal."

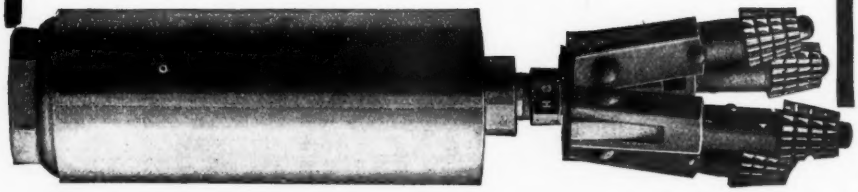
THE LAGONDA MFG. CO., Springfield, O.

Makers of Lagonda Automatic Cut-Off Valves, Reseating Machines and Tube Cutters. 76

New York Philadelphia Pittsburg Chicago San Francisco Birmingham Toledo London



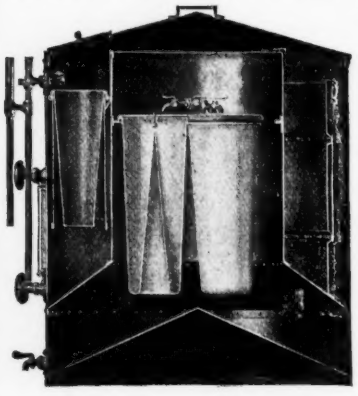
TRY LIBERTY DEVICES



You'll find them different from any of the ordinary similar devices you are familiar with. They do their work more thoroughly—and in the case of the Turbine Cleaners, in less time.

Speaking of the Cleaners, a Liberty Heavy Duty Turbine Cleaner will clean a four-inch eighteen-foot tube full of scale one-inch thick in *twenty minutes*. That's going some!

Note the twin construction of the Liberty Twin Strainer. It never stops work for an instant, as one side can always be kept open when the opposite side is being cleaned.



Doubtless you are familiar with the common type of oil filter that vainly tries to purify the oil by washing it and passing it through bone dust, excelsior, charcoal, etc. In the Liberty Oil Purifier, 90% of the work is done in the settling chamber. Experience has proved this method to be the one that really *refines* the oil – every drop.

WRITE FOR CATALOG.

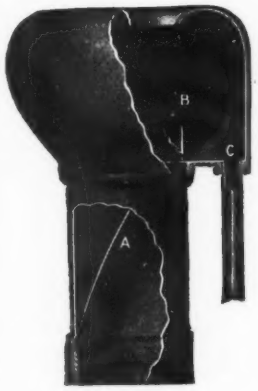
LIBERTY MANUFACTURING CO.,

6509 SUSQUEHANNA ST., PITTSBURG, PA.

There is "Nothing Simpler" than the

"SWARTWOUT"

Cast Iron Exhaust Head



Nothing but the helical tube and the shell.

Direct Flow—No baffle plates.

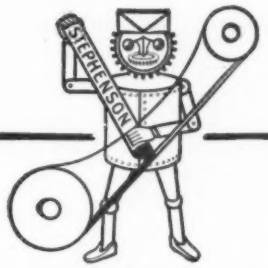
Absolute separation of all water and oil by the vigorous whirling motion.

THE OHIO BLOWER CO.

CLEVELAND, OHIO.

Also manufacturers of "Swartwout" Gravity Closing Ventilators.

1-42



THE AFTER EFFECTS ARE PLEASANT

Don't waste good belts and lose valuable power. **STEPHENSON Bar Belt Dressings** contain no Rosin nor any other ingredients injurious to Belting. Our **RED Label** and **GREEN Label Brands** are two entirely different and distinct preparations. No **one** kind of Dressing is good for **all** Belts—you know that. **STEPHENSON Dressing** not only prevents slipping and gives full speed from slack belts, but **the after effects are pleasant**—it KEEPS those belts in good condition and greatly prolongs their life.

This means a saving in BELTING, which is an important item when figuring the year's expenses.

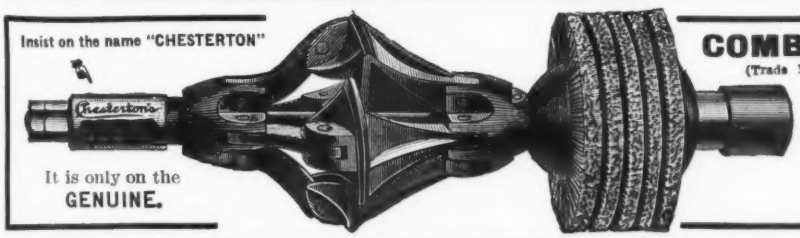
RED Label Brand for Leather belts;
GREEN Label for Rubber and Canvas.

Your protection against substitution is **The Man with the Cog-Wheel Face** on each Pound Stick.

Of Dealers everywhere, or

STEPHENSON MFG. CO.
ALBANY, N. Y

Insist on the name "CHESTERTON"



It is only on the **GENUINE.**

COMBINATION Scraper and Brush

(Trade Mark Registered)

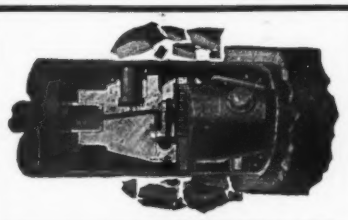
It is "TWO TOOLS IN ONE." The chilled scrapers remove the scale and the work is finished up by the brush. Tubes can be made **like new** in one operation.

A. W. CHESTERTON CO., 84 INDIA STREET, BOSTON, MASS.

Or Advance Packing & Supply Co., 123 Franklin St., Chicago.

THE "TORPEDO"

Removes all scale from tubes of fire tube boilers.
Saves 11 per cent. of fuel for each 1-16 inch of scale.
Prolongs life of tubes.
Saves compound.
Centers itself in tube.
Strikes same in every direction.
Stroke limited and cushioned.
Does not hammer but vibrates the tube.
Is absolutely safe and easily operated.
Has but one moving part.
Will last a lifetime.



The "Torpedo"

THE IDEAL CLEANER FOR FIRE TUBE BOILERS.

We invite every plant using fire tube boilers to send for a "TORPEDO" on free trial. If it isn't the best cleaner you ever saw, don't buy it. Every engineer should have a copy of our free circular No. 30, "How to Tell a Good Fire Tube Cleaner." For water tubes, send for circular No. 54 on straight tube, or No. 56 on curved tube "DEMON."

THE GENERAL SPECIALTY CO., 887 Niagara St., **Buffalo, N. Y.**

Do You Use Flexible Tubing?

Pennsylvania Flexible Metallic Tubing is made of the finest quality copper or galvanized steel tape rolled in one continuous length to spiral form so that the edges interlock about an asbestos packing thread.

Made in all sizes $\frac{1}{8}$" *to* 12" *for high pressures of all liquids, gases, etc.* Write.

Pennsylvania Flexible Metallic Tubing Co.,

H. A. ANSELL **1305 Arch St., Philadelphia, Pa.** S. H. COLLOM

New York, 86 Warren St. Boston, 71 High St. Detroit, 601 Stevens Bldg. Chicago, 255 LaSalle St.

FOR WORK IN PLACES WHERE OTHERS FAIL

DUXBAK BELTING
TRADE MARK

"DUXBAK" LEATHER BELTING

Will always give highest grade results and will last indefinitely. Both the Steamproof and Waterproof can be relied upon for perfect service. Sent on approval in every case.

Chas. A. Schieren Company
ESTABLISHED 1868

Tanners, Belt Manufacturers. **69 Cliff St., New York.**

Chicago, 84-86-88 Franklin St. Pittsburg, 240 Third Ave. Boston, 186-188 Lincoln St. Denver, 1622 Wazee St. Philadelphia, 226 North Third St. Brooklyn, N. Y., 13th St. and 3rd Ave. Hamburg, Germany, Auf dem Sande 1. OAK LEATHER TANNERIES, Bristol, Tenn.

READ THIS BOOKLET

It explains why

SHULTZ SABLE AND Aqua Water Proof Rawhide Belting

are so much better than ordinary belting It further backs up our claims to superiority with opinions of representative manufacturers and power plant engineers about Shultz belts which have been in use from 10 to 25 years. Write for the booklet, or better yet, tell us your requirements and get a trial belt for 60 days' free use. If you don't like its performance you can send the belt back.

SHULTZ BELTING CO., ST. LOUIS, MO.
NEW YORK BOSTON PHILADELPHIA 34a

Robins Laminated Leather Belting

Is made continuous without laps, plies or cement. Guarantees an equal distribution of strength and an uninterrupted line of power transmission.

Write for circular No. 2.

ROBINS NEW CONVEYOR COMPANY
New York, 38 Wall Street — Factory, 168 Duane Street — Chicago, Old Colony Bldg.

SAGINAW MANUFACTURING CO.,
SAGINAW, MICH., U. S. A.
MANUFACTURERS OF
GILBERT WOOD SPLIT PULLEYS.
New York Branch, 88 Warren Street.
Chicago Branch, 32 South Canal Street.
Sales Agencies in all principal cities.
Cable Address, "Engrave" A. B. C. and Lieber's Code.

Belting Logic—If best Leather Belting costs per sq. ft. $1.00, best Rubber Belting 60c., and best Stitched Canvas Belting 40c., and with Leather showing 25% and Rubber 50% of the strength of **Best Stitched Canvas Belting,** wouldn't it be good policy for you as a practical man to investigate the merits of our product? Send for Book "C."

SAWYER BELTING COMPANY, **CLEVELAND, OHIO.**

OXoilOX

THE PERFECT BELT DRESSING

MADE from pure neatsfoot oil, but as different and improved as broad cloth is over raw wool. Contains absolutely **no** resin or tallow; nothing to make belts heavy or sticky; it's a **"food"**, not a dope; it restores to leather the strength and vitality lost in tanning; keeps belts soft, and tough and clean. There's **"life"** in them when treated with **OXoilOX.** They cling so closely to pulleys that air is absolutely excluded, and the belts run slack at full load without slipping.

Saves the belt, saves the bearings, saves power; —you "need it in your business."

F. S. WALTON CO., Philadelphia.
Gentlemen:—Kindly send us free of all charge, a sample can of OXoilOX, the perfect belt dressing.

Name..... Name of Firm.....

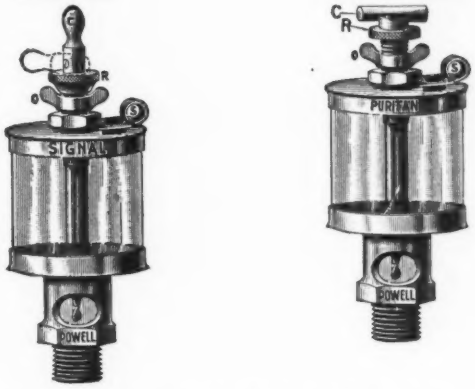
Address..... Number of Belts..... Average size.....

F. S. WALTON CO., Philadelphia, Pa.
Pressers and Refiners of all grades of Neatsfoot Oil.

The two most reliable Oiling Devices for every steam engineering purpose.

The POWELL

SIGNAL **PURITAN**



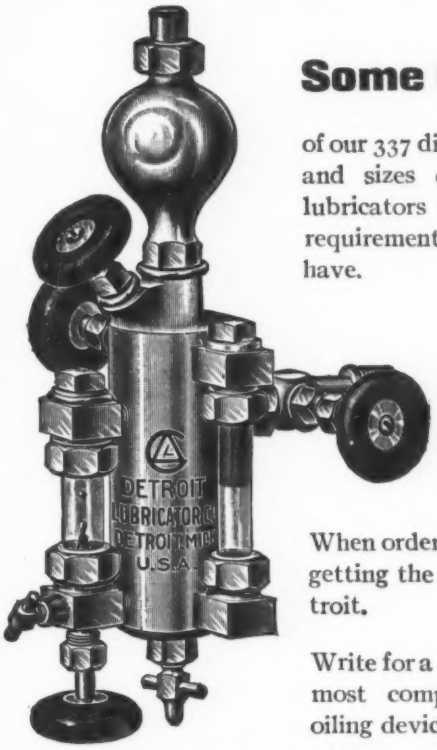
they work on a simple and effective principal that insures absolute regularity of feed. Once set, it never changes.

There is a difference in the price between the two which is explained in the circular—a postal will bring it to you.

We are mailing the second edition of our catalog
Would YOU like a copy?

The WM. POWELL COMPANY,
CINCINNATI, OHIO.

New York: 254 Canal St.
Boston: 239-45 Causeway St. Philadelphia: 518 Arch St.



Detroit Improved Standard Lubricator

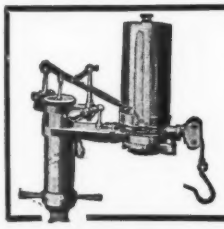
Some One

of our 337 different styles and sizes of sight-feed lubricators will fill any requirement you may have.

When ordering, insist on getting the genuine Detroit.

Write for a catalog of the most complete line of oiling devices for all purposes.

DETROIT LUBRICATOR COMPANY.
Detroit, U. S. A.



None Better At Any Price

and all other standard indicators cost at least $50 more than the Trill. *Write.*

The Trill Indicator Company,
Eagle Street, Corry, Pa.

RHOADS LEATHER BELTING

The one specification—it gives the service

J.E.Rhoads & Sons

PHILADELPHIA 12 N. THIRD ST. BOSTON NEW YORK 40 FULTON ST.
HAMBLET & HAYES CO. EASTERN AGENTS, 105-111 SUMMER ST.
FACTORY WILMINGTON, DEL.

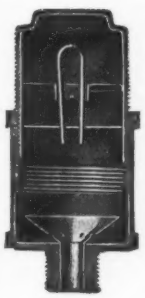
ALL PARTS Interchangeable

The Akron Clutch is easily applied to the shaft, the entire operating mechanism being handled as one piece.

BOOKLET?

The Williams Foundry & Machine Co.,
Successors to the Akron Clutch Co. AKRON, OHIO.

The "Philadelphia" Grease Cup



Automatic application of grease to the bearing without the use of spring compression. : : : :

Nature Supplies the Feeding Force in the Form of Compressed Air. : : : : :

With many thousands of the "Philadelphia" Grease Cups in successful operation, on machinery of almost every description, we offer a system of lubrication which, for simplicity, cleanliness, economy, reliability and efficiency has no equal.

The "Philadelphia" Cup is not merely "as good as any other:" IT IS THE BEST, and we are prepared to prove our claim for actual superiority. There are more reasons for its practical success than we have room to mention here.

Write for catalogue and full information.

The Philadelphia Lubricator & Manufacturing Co.
The Bourse (Exhibition Dept.), **Philadelphia, Pa.**

Power Handbooks

Pipes and Piping

General rules for the design of high and low pressure steam piping in power plants. Ideas of forces to be met and the amount of resistence that can be expected from pipes and fittings properly placed. Good steam-pipe design for all size plants. Suggestions as to installation and operation. Estimating stock for covered pipes. Packing. Bursting strength. Accidents. Practical suggestions. Sizes. Conduits, etc. 140 pages. Fully illustrated.

Erecting Work

Designed for erecting engineers and to enable men in charge of power plants to erect their own machinery. Foundations. Knots and hitches. Hauling heavy machinery. Runways. Work for a gin pole. Rigging for the receiver. Moving a cylinder. Unloading a heavy shaft. Rigging for a heavy lift. Building up a fly wheel. Some of the lighter work, etc., etc. 140 pages. Fully illustrated.

$1.00 each postpaid

Take Your Choice of the POWER HANDBOOKS

and be certain of one thing—you'll have in one book the best information pertaining to its subject that is to be found in print.

Every reading engineer—and this means every engineer who believes in reaching out beyond the limit of his own experience—will find in the Power Handbooks just the class of books he has been looking for. The aim has been to give in one book all the best information on its subject, so that you may choose those subjects which interest you most and not be compelled to wade through a mass of unwanted information to get at what you need.

Another aim has been to make them thoroughly *practical* in contents and presentation. No abstract theories are given, no fancy stunts, no fluted frills nor peek-a-boo effects—nothing but solid engineering *facts* presented in solid English.

With the exception of Engine-Room Chemistry by Augustus H. Gill, the books have been compiled from an enormous amount of available material by Hubert E. Collins, one of the best known writers on engineering subjects.

The stiffest problems you can get up against are solved for you here; the commonest troubles are not overlooked. It isn't altogether a question of solving present-day troubles. It's learning things that you have never dreamed of but that will help you to promote the efficiency of your plant and *yourself*. On that ground we recommend these books to you and *guarantee* them to be as represented—and you're the judge and jury.

Guarantee

Send us $1.00 for each book wanted. If upon examination, they are not *entirely* satisfactory to you, return any or all within 5 days of receipt and we'll refund your money at once. This is as fair an offer as can be made. A wise move is to take advantage of it TODAY!

Fully illustrated. Cloth bound.
Price, $1.00 each, postpaid.

HILL PUBLISHING CO.,
505 Pearl Street, New York.
Publishers of POWER AND THE ENGINEER

Power Handbooks

Knocks and Kinks

Showing "Kinks" that will eliminate Knocks. Causes. Cylinder noises. Ready detection and remedy. Effect of inertia. Rigging up to turn and refit. Repairing broken cylinder. Removing tight piston rod. Marine practice. Re-babbiting engine boxes. Keying up crank pins. Testing. Practical kinks. Emergency repairs. Temporary repairs. To find dead center, etc. 137 pages. Fully illustrated.

Engine-Room Chemistry

Shows where money can be saved and efficiency promoted through applying some simple rules of chemistry. No previous knowledge of the subject required. Flue gas analysis and combustion regulation. Feed water analysis and how to prevent scale, etc. Lubricant analysis. Fuel analysis, etc., etc. 198 pages. Fully illustrated.

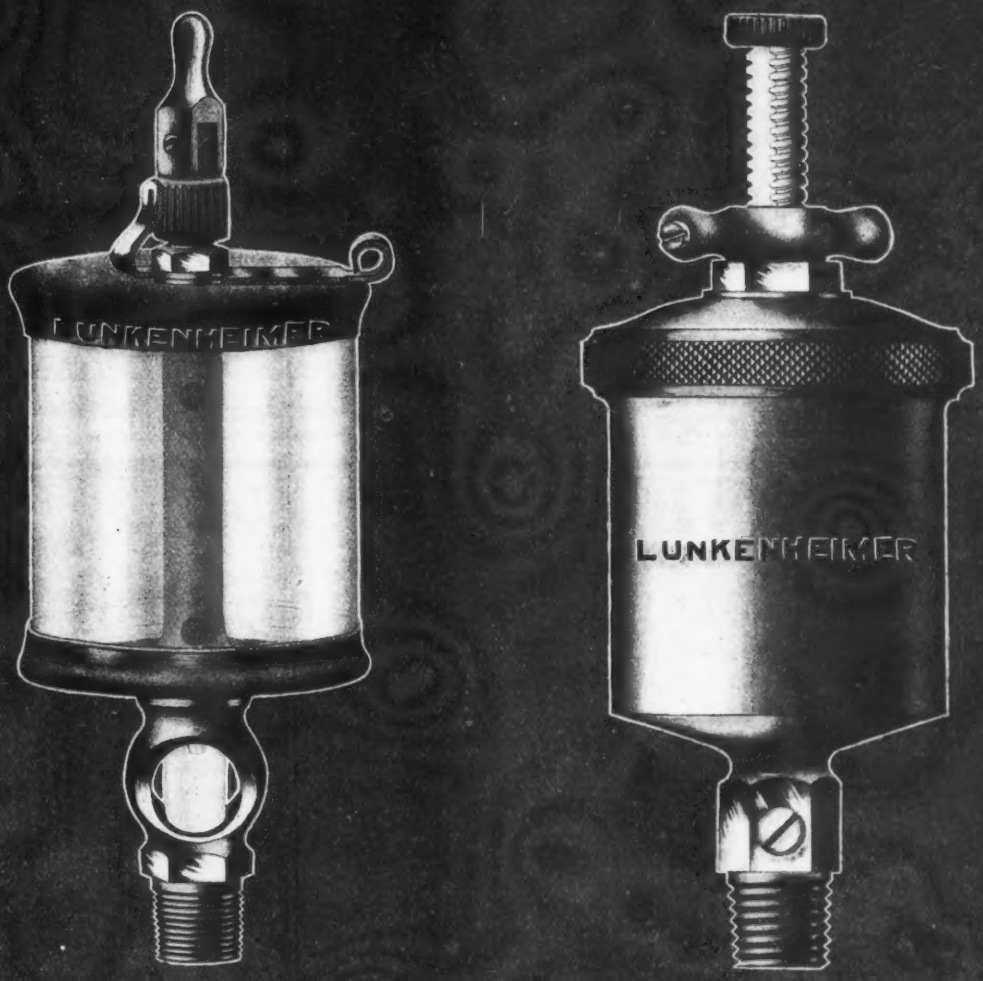
$1.00 each postpaid

Good OIL or GREASE CUPS ought to last a lifetime. They should have NO COMPLICATED PARTS and should be made of CAST (not spun) BRASS. The feed ought to be easily regulated, and the flow steady and positive.

Lunkenheimer Oil and Grease Cups

are designed according to above specifications.

Largest and most complete line made. Write for catalog.



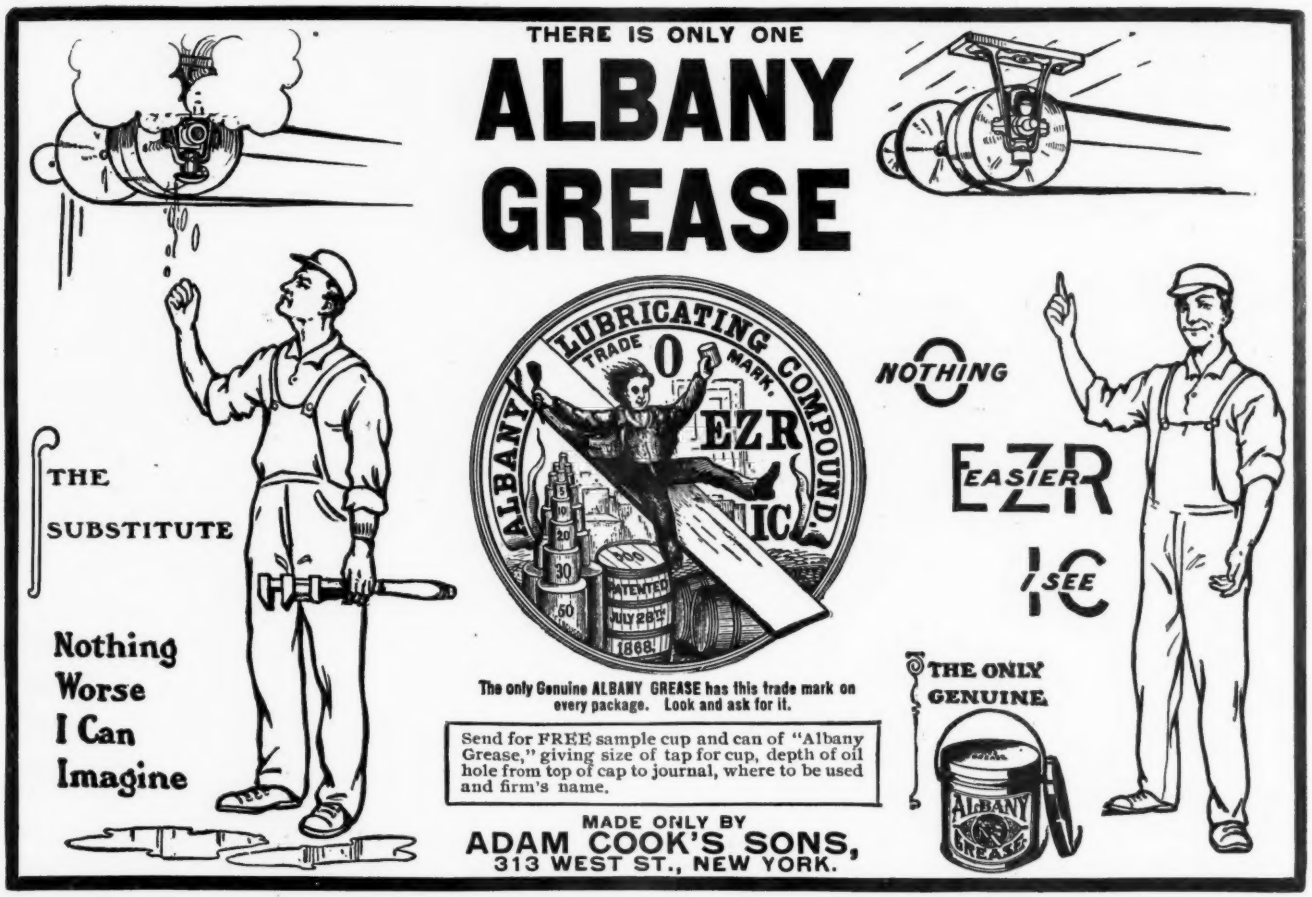
7

The Lunkenheimer Company

Largest Manufacturers of High Grade Engineering Specialties in the World

General Offices and Works, Cincinnati, Ohio, U.S.A.

Branches: New York, 66-68 Fulton St.; London, S.E., 35 Great Dover St.; Chicago, Lake and Dearborn Sts.


THERE IS ONLY ONE
ALBANY GREASE
THE SUBSTITUTE
Nothing Worse I Can Imagine
LUBRICATING COMPOUND
TRADE MARK.
ALBANY
EZR
IC
PATENTED JULY 28TH 1868
NOTHING
EASIER
EZR
I SEE
IC
The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.
Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.
MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.
THE ONLY GENUINE
ALBANY GREASE

The Advantages of Using Graphite

for lubricating the cylinders of air compressors are stated as follows by those who have had experience:

DIXON'S FLAKE GRAPHITE

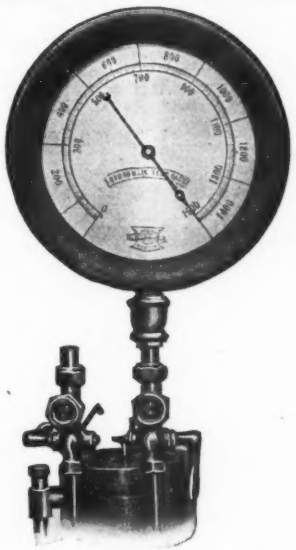
cannot possibly give off explosive vapors, cannot be carbonized or ignited, is unaffected by high temperatures, will not clog discharge valves, will not accumulate dust or grit, and allows a great reduction in oil costs.

JOSEPH DIXON CRUCIBLE COMPANY
JERSEY CITY, NEW JERSEY

Latest Improved

ROCHESTER

Automatic Lubricators



They will pump against high pressures and give "perfect force feed lubrication."

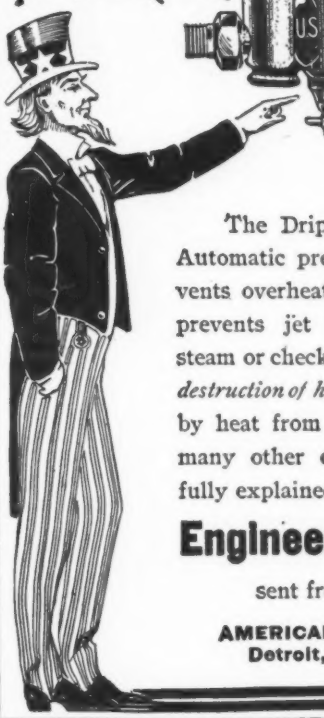
SEND FOR CATALOGUE.

GREENE, TWEED & CO.,
109 DUANE ST., NEW YORK.

No Freezing Here

The Drip Cock prevents it

U.S. Automatic Injector



The Drip Cock of the U. S. Automatic prevents freezing; prevents overheating of suction pipe; prevents jet "liming up" when steam or check valve leaks; *prevents destruction of hose on traction engines* by heat from hot water, and has many other exclusive advantages fully explained in our

Engineer's Red Book

sent free on request.

AMERICAN INJECTOR CO.
Detroit, Mich., U. S. A.

Chicago Automatic Injector

Chicago Automatic Injectors

Prove their Quality in Actual Operation

No boiler feeding troubles when you have a powerful Injector that is built for service.

The Chicago Guarantees a Full Boiler when you want it

It is positive in its work and has nothing to get out of order. Built unusually strong.

THE BEST PROTECTION FOR BOTH BOILER AND ENGINEER

You cannot afford to be without it. It makes the power plant complete.

THE CHICAGO EJECTOR, a powerful little instrument for elevating, forcing and conveying liquids. Does marvelous work with but little steam.

Write for description and catalog of both the Chicago Injector and Ejector.

THE OHIO INJECTOR COMPANY,

The World's Greatest Injector Manufacturers.

WADSWORTH **110 Main Street** **OHIO, U. S. A.**

Chicago Ejector

Westinghouse

New Model Roney Stoker

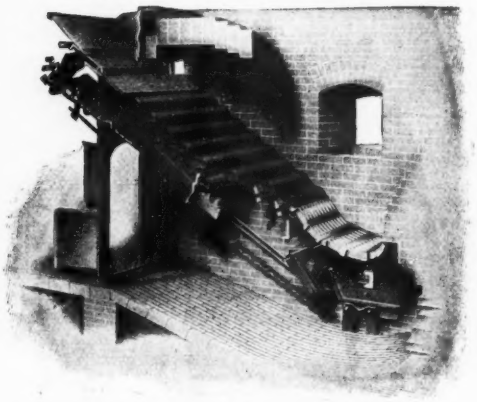
New Grate Bar

has eight feet of cooling surface for every square foot of surface exposed to the fire.

New Arch Construction

by which the air supply above the fuel bed is preheated and delivered at the best point to insure smokeless operation.

Send for Illustrated Folder 4004.

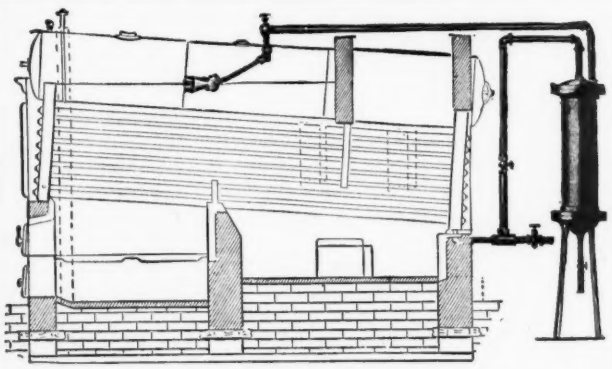


New Model Roney Stoker in Perspective

The Westinghouse Machine Company,

Steam Turbines, Steam Engines, Gas Engines, Gas Producers, Storage Batteries and the Roney Stoker

New York, 165 Broadway.
Boston, 131 State Street.
Cleveland, New England Building.
Atlanta, Candler Building.
Chicago, 171 La Salle Street.
Cincinnati, Traction Building.
St. Louis, Chemical Building.
Pittsburg, Westinghouse Building.
Philadelphia, North American Bldg.
Denver, 512 McPhee Building.
San Francisco, Hunt, Mirk & Co.



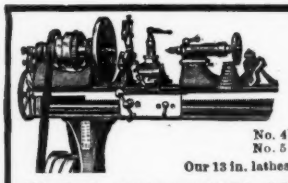
Remove The Things That Cause Scale,

the scale-forming impurities themselves, and you'll have no use for boiler compounds or mechanical cleaners. The

BUCKEYE BOILER SKIMMER

automatically skims the scum off the surface of the water in the boiler and deposits it in an exterior filter. After the first cost, it will cost you nothing to *keep* your boilers free from scale and mud. We have the proof—lots of it. 30 days' free trial allowed. Write for details.

Buckeye Boiler Skimmer Company,
SOUTH END, TOLEDO, OHIO.



"The BARNES"
LATHES
W.F. AND J.C.
9 in. to 13 in. Swing.
No. 4½ Lathe, 9 in. x 25 in., List $ 75.00
No. 5 Lathe, 11 in. x 34 in., List 100.00
Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.
W. F. & JOHN BARNES CO., 990 Ruby Street, Rockford, Ill.

THE HAWK-EYE BOILER COMPOUND

NEVER FAILED.
See our Advertisement in First Issue Every Month.
HAWK-EYE COMPOUND CO.,
303-304-305 Merrick Block, CHICAGO, ILL.

Scalelessness Guaranteed

Use Pyramid Boiler Compound and your boilers will be absolutely scaleless. WE GUARANTEE IT. Write for information.

Binghamton Boiler Compound Co.
Binghamton, New York.
Los Angeles, Cal.; Seattle, Wash.; Portland, Oregon; Cincinnati, Ohio; Cleveland, Ohio; Providence, R. I.; Syracuse, N. Y.; Scranton, Pa.; Louisville, Ky.; St. Louis, Mo.; Birmingham, Ala.

GRAPHLIO

mixed with your oil saves 40 to 60% of your lubricant costs. Write.

WALTER D. CARPENTER & CO.
39 Cortlandt St., New York.

An Automatic Boiler Room

self-feeding, self-operating and self-cleaning.

The Wilkinson Automatic Stoker And Smoke Preventer

makes the boiler room the least troublesome, least expensive and at the same time the most efficient part of the plant. Our catalog tells how to save 5 to 15% of your fuel cost.

The Wilkinson Manufacturing Co.,
Bridgeport, Montgomery County, Pa.

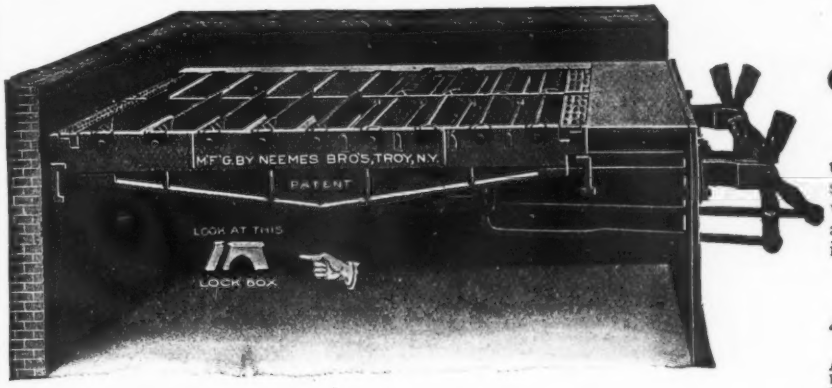
JEFFREY TELESCOPIC ASHES ELEVATOR.

Jeffrey

Coal and Ashes Handling Systems for Power Plants.

THE JEFFREY MFG. CO., COLUMBUS, OHIO.

New York Chicago Boston St. Louis Denver Pittsburgh Montreal Knoxville



NEEMES BROS.

IMPROVED

Clinker Cutting, Shaking and Dumping Grate

unlike all other grates will cut from both sides of the shaker alike. Makes more steam with cheaper fuel and less of it. A slight agitation shakes out the ashes or a full opening dumps everything into the ashpit. *Write.*

NEEMES BROS.,
41-49 Adams St., TROY, NEW YORK

C. W. VAN BLARCOM, Room 533, Terminal Bldg., 30 Church St., Agent for New York City and vicinity. BABCOCK & WILCOX, Ltd., Montreal, Canada, Sole makers for Canada. BURKE ENGINEERING CO., 311 Industrial Bldg., Providence, R. I., Sole Agents for the New England States.

Triplex Blocks

Y. & T. Triplex Blocks have forged bendable hooks, chain which is accurately gauged and tested link by link, sheave pockets which fit the chain absolutely, and the load is sustained by a Weston brake.

Sold by hardware dealers everywhere.

Y. & T. Triplex Blocks are the perfect hoist for every lifting operation that demands absolute freedom from jar or vibration and insures careful speed control. Made in capacities from one-half to twenty tons at one man power.

Write for catalog.

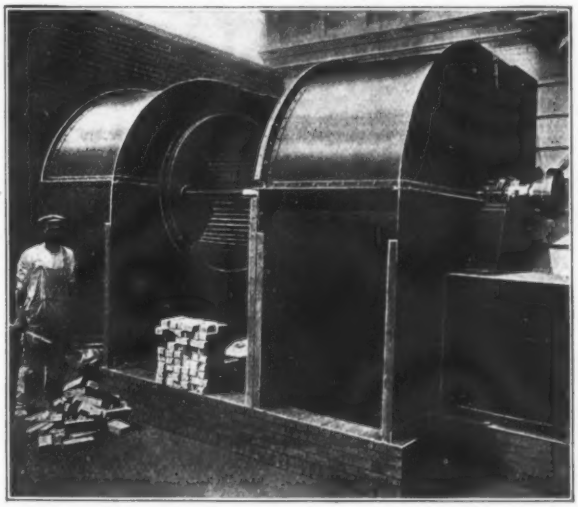
Yale & Towne Mfg. Co.
9 Murray Street, New York

"SIROCCO"

TRADE MARK

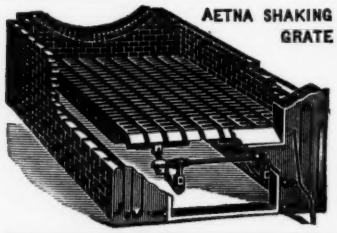
BLOWERS

BUILT ON THE TURBINE PRINCIPLE
MOST EFFICIENT FOR ALL DUTIES



VENTILATING INSTALLATION, HOTEL ASTOR, N. Y.
Two 66 inch Sirocco fans running on one shaft. Capacity: 50,000. cu. ft. per minute each against ¾ in. W. G. Power saving 25%

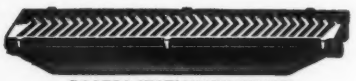
SIROCCO ENGINEERING CO.
138-140 Cedar St., New York. **Works: Troy, N. Y.**



SALAMANDER GRATES

Twenty different styles, all made of same grade of iron—the best for the purpose. On the market for 55 years. Tried and true.

SALAMANDER GRATE BAR CO.
126 Liberty Street, New York


ROGERS STATIONARY GRATE

MARTIN GRATES

Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.

MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.

THE MONARCH BOILER ARCH

is composed of a metallic backing faced with fire brick or other similar material. It hangs from above and never crowds out the brickwork. Booklet?

MAYVILLE SPECIALTY MFG. COMPANY, Mayville, Wis.
General Founders and Machinists

GREEN CHAIN GRATE STOKERS
AUTOMATIC SELF-CLEANING SMOKELESS
GREEN ENGINEERING CO.
COMMERCIAL NATIONAL BANK BLDG., CHICAGO
GENERAL FOUNDRY WORK A SPECIALTY

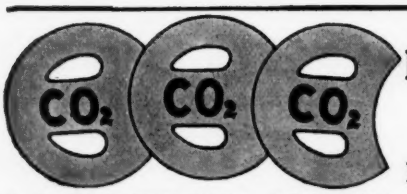
There's Lots Of Money

in getting high-priced results from low-priced fuel. The Wing's Turbine Blower shows how—ask about it.

L. J. Wing Mfg. Co., 90 West St., Cor. Cedar Street, New York.

CONTRACTORS.
CENTRAL STATION HEATING.
Write for valuable information.
AMERICAN DISTRICT STEAM CO.,
Lockport, N. Y. Toronto, Can. Chicago.

ANY TYPE OF BOILER
The Murphy Automatic Smokeless Furnace
burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.
MURPHY IRON WORKS, 5 Walker St., DETROIT, MICH.
UNITS OF ANY SIZE



C-O-Two Tile
FIRE ARCHES
Any Rise, Any Span,
Air Baffle Mixing System
produces
RESULTS
C-O-TWO FURNACE COMPANY, Syracuse, N. Y.

PREVENT SMOKE

Write to us for descriptive matter relating to a device that is mechanically correct, simple in construction, absolutely automatic, and its effectiveness in preventing smoke from Bituminous coal under any and all conditions has been fully demonstrated.

CLIMAX SMOKE PREVENTER COMPANY
205 Equitable Building, Boston, Mass.

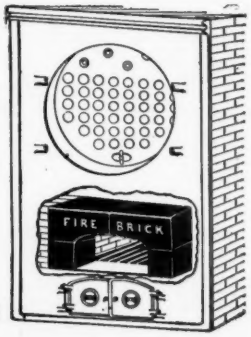
CHIMNEYS

WIEDERHOLDT CONSTRUCTION CO.
American Trust Bldg., Chicago, Ill.

Over 7500 Hammel Oil Burners
In use under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers
HAMMEL OIL BURNER CO.
609 North Main Street, LOS ANGELES, CAL.

BOILER DOOR ARCH and JAMBS made of
NON-SHRINKING FIRE BRICK

The perfect mould, close fit and smooth, solid surface make them remarkably durable.
Write for booklet.

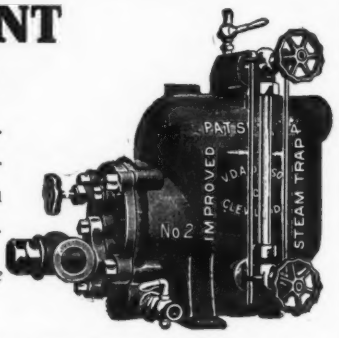


PRESBREY FIRE BRICK WORKS
D TAUNTON, MASS.

A SEDIMENT CHAMBER

in the Anderson Improved Steam Trap prevents sediment from getting into the valve.

Ask for full descriptive particulars.



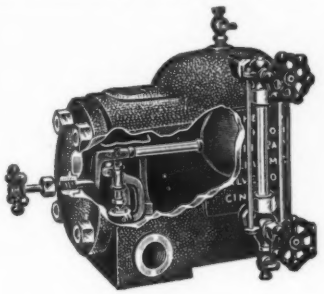
THE V. D. ANDERSON CO.,
1935 West 96th Street CLEVELAND, OHIO.

Buy a Trap That You Can Depend Upon.

WHEN you buy a steam trap, you naturally expect to get one that is of simple and durable construction and which will *trap* your condensation *without any loss of steam.* Traps that leak steam are a wasteful proposition because every pound of steam lost in this manner represents a certain amount of money lost in fuel. If you wish to avoid trouble of this kind, buy a trap that you can depend upon—in other words order a

Cookson High Pressure Steam Trap.

It is without any question of doubt, the simplest, most durable and reliable steam trap ever made. The working parts are few in number and the construction is so simple that there is no chance of the Cookson ever giving you any trouble. It automatically receives and discharges condensation without any loss of steam, because the valve is constantly submerged below a seal of several inches of water.



Want a Catalog?

THE D. T. WILLIAMS VALVE CO.
904-910 BROADWAY, - CINCINNATI, OHIO
11

ALL WE ASK
IS A FAIR TRIAL

GEIPEL STEAM TRAPS ARE IN USE FOR ALL CLASSES AND CONDITIONS OF SERVICE.
THEY HAVE STOOD THE TEST.
Write for circulars.

John Platt & Co., 97 Cedar St., New York.

VALUABLE INFORMATION

Send us your name and address on a postal and we'll send you full particulars regarding the **Morehead Steam Trap.** This trap is unlike all others. We want to place our Catalog in your hands and have you read it from cover to cover. It will open your eyes.

Morehead Manufacturing Co.
1051 Grand River Ave., Detroit, Mich.

Which is the Trained Man's Home?

It's in the home where training affects you most. It's in the home where the size of your pay envelope really counts. The **trained** man who holds a responsible position paying a good salary is able to have a home in which are found the luxuries of life.

The **untrained** man, who cannot do any one thing well, who must work by the day at jobs paying low wages, must put up with many hardships and do without a great many of the comforts of life.

But such a man can better himself if he chooses. An institution backed with a capital of six million dollars, whose sole business for 17 years has been to raise the salaries of ambitious men, will help him.

If **you** wish to better your position, increase your salary, and secure a happy and successful life, it is your duty to mark and mail this coupon. If your work is uncongenial, if you desire to advance in your trade, if you wish a better salary, find the way that thousands upon thousands of men have made their start for promotion and multiplied earnings. You do not have to leave home, buy books, or give up your present work. This is the most practical and simplest way in the world to secure promotion, so if you really want a better salary and a happy life, **make a definite attempt to get it by sending in this coupon NOW.**

International Correspondence Schools
Box 979, Scranton, Pa.

Please explain without further obligation on my part, how I can qualify for a higher salary and advancement to the position before which I have marked X.

Electrical Engineer	Machine Designer	Sanitary Engineer
Elec.-Lighting Supt.	Mechanical Draft.	Architect
Elec.-Railway Supt.	Foreman Machinist	Architect'l Drafts.
Electrician	Foreman Toolmaker	Ad Writer
Telephone Engineer	Foreman Molder	Window Dresser
Civil Engineer	Foreman Blacksmith	Chemist
Bridge Engineer	Marine Engineer	Sheet-Metal Draft.
Mechanical Engineer	Hydraulic Engineer	Ornament. Design.
Stationary Engineer	Municipal Eng.	Textile Designer
Gas Engineer	R. R. Const. Eng.	Bookkeeper
Refrigeration Eng.	Surveyor	Stenographer
Traction Engineer	Mining Engineer	Civil Service Exams.

*Name*_____
*Street & No.*_____
*City*_____ *State*_____

KITTS SPECIALTIES

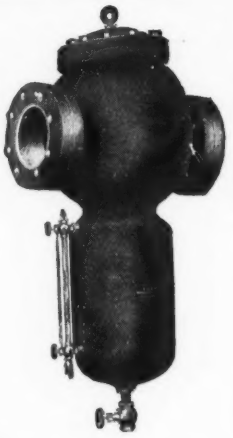
Pump Governors,
Reducing Valves,
Steam Traps,
Safety Feed Water Regulators,
Fan Engine Regulators.

Low Water Alarms,
Safety Water Columns,
Damper Regulators,
Low Pressure Boiler Feeders,
Vacuum Pressure Reducing Valves.

Catalog?

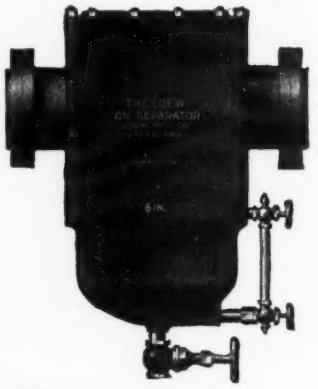
KITTS MFG. COMPANY,
OSWEGO, NEW YORK.

The Loew Separators



are best to buy because they give the best results.

It is needless to impress upon you the importance of



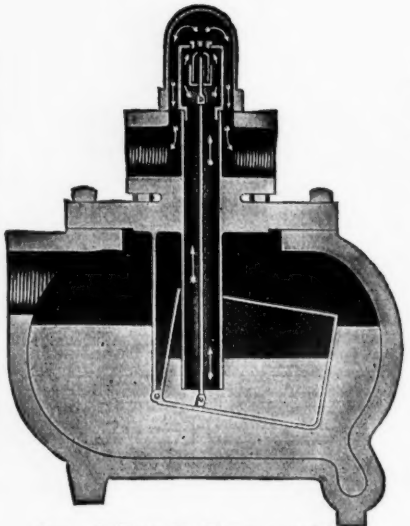
Steam and Oil Separators in your plant. Your problem lies, not in deciding whether to install them, but rather *which make* to install.

Before placing your order, study up on the "Loew." Our catalog is ready for you.

The Loew Mfg. Co.,
Cleveland, Ohio.
New York Representative,
G. L. TODD, 50 Church Street.

Our Steam Traps

4/S



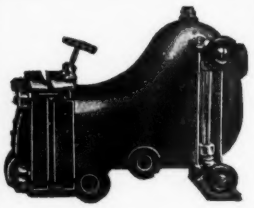
One of Strong's Steam Specialties.

are built for long hard service and with the idea that you will want ours when next in the market. We are proud of our reputation.

Send for Catalog "A" of complete line.

THE STRONG, CARLISLE & HAMMOND CO.
342 Frankfort Ave., CLEVELAND, O.

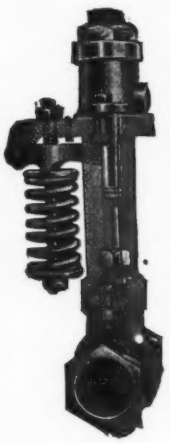
261 Centre Street, New York
88 Broad Street, Boston
54 No. 6th Street Philadelphia



McDANIEL STEAM TRAPS

are especially adapted for draining steam separators and high pressure mains. Also good for steam heating. All working parts are attached to the bonnet, and are removable with it. Valve outlets are large, to give rapid discharges of condensation.

Watson Steam Pump Governor



should be used on all steam pumps where a fixed discharge pressure is desired.

The construction permits of easy access to the stuffing box for removing packing, and the spring can be adjusted or entirely removed without interfering with any other part of the valve. Any practical man will readily see its advantages.

All our goods are made in our own factory and tested before shipping. We guarantee them to give perfect satisfaction. Established 1878.

Send for Catalogue.

Watson & McDaniel Co.,
148 North 7th Street, Philadelphia, Pa.

Buying, Selling Or Using Steam

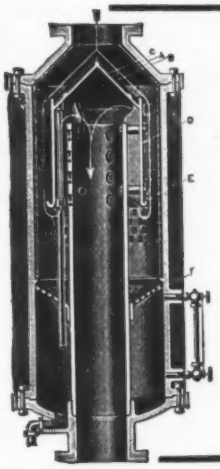
without measuring it, is just as careless and unbusinesslike as buying selling or using coal by guess.

This meter is also adapted to the measurement of water, air and other gases.

DETAILS?

G. C. ST. JOHN
140 Cedar Street,
NEW YORK

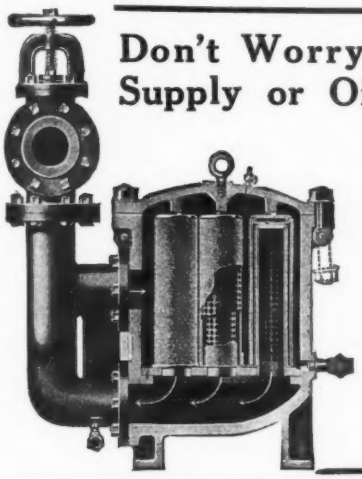
The St. John Indicating and Recording Steam Meter



SWEETS

Steam Separators deliver 99.8 dry steam and oil separators remove 99% of oil from exhaust steam. They *do* it that's all. All styles.

DIRECT SEPARATOR COMPANY,
712 S. Geddes St., Syracuse, N. Y.



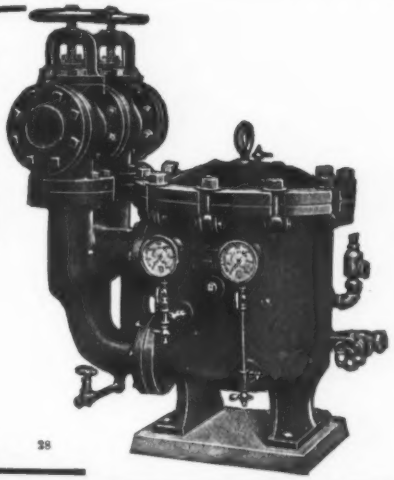
Don't Worry About Dirt in the Water Supply or Oil in the Condensed Exhaust

Just Put A **BLACKBURN-SMITH FEED WATER FILTER AND GREASE EXTRACTOR**

in the feed line, and you have the one effective means of removing these impurities. Two SEPARATED layers of linen terry do the work. What the first layer doesn't catch, the second does. No other filter gives this DOUBLE filtration, or can be kept clean with so little effort or expense.

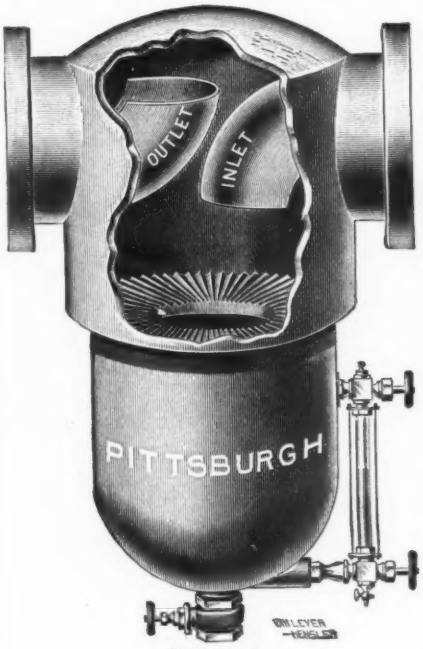
Write for book "Feed Water Filtration."

JAMES BEGGS & CO.,
106 Liberty St., New York City



38

"Pittsburgh" Steam Separators



Horizontal

For Live or Exhaust Steam

Utterly Simple **Perfectly Effective**

Highest Efficiency—
Proved by Laboratory Tests.

No Baffle Plates—
To Cause Spattering Back.

No Contracted Areas—
To Retard Freedom of Flow.

No Small Passages—
To Foul and Clog.

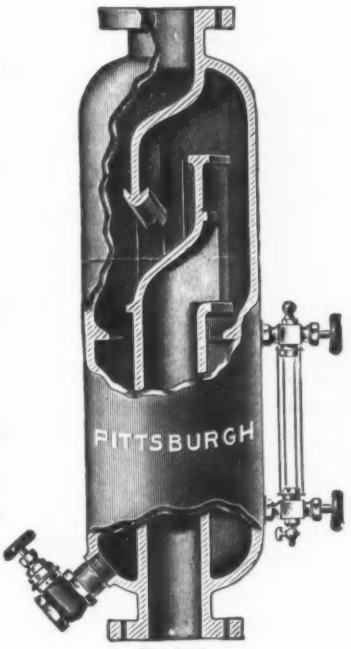
Perfect separation secured by sudden changes in direction of steam flow.

Separated water and oil drained directly away from steam current and into protected receiver space.

Horizontal and Vertical Types

Plain and Receiver Styles

Made in all sizes—Shipped on Guarantee Trial.



Vertical

Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

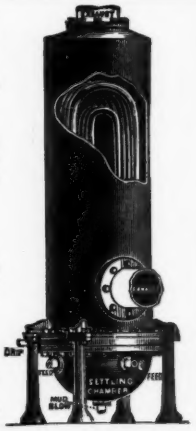
Almost Boils Feed Water

and requires no more steam than the less efficient heaters.

Patterson-Berryman Feed Water Heater and Purifier

is easier to clean or repair and requires less cleaning and fewer repairs than any other device for the purpose.

Have our 60-day free trial offer?



Frank L. Patterson & Co.
28 Cortlandt St., New York, U. S. A.

IT'S UP TO YOU

After you order a Baum Separator, whether or not you pay for it. You can use it **free** for a month and if you decide you don't want it, we'll pay the cost of sending it back to us. Could anything be fairer?

CATALOG?

THE HERSHEY MACHINE & FOUNDRY CO.
MANHEIM, PENNSYLVANIA.
W. G. Ruggles Co., 54 High St., Boston, Mass.
R. D. Bliss, 40 Dearborn St., Chicago, Ill.

Here's A New Shell Game

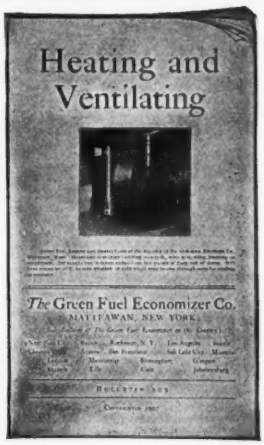
Don't padlock your pockets; you're not going to get stuck.

The ordinary feed water heater, you know, has a single shell. Consequently it loses heat through radiation—no matter how good its other points are.

We've worked out a "Shell Game" that prevents this. The BARAGWANATH Steam Jacket Feed Water Heater (as shown by the cut) consists of a shell within a shell. The inside tubes heat the water; the jacket of steam between the shells keeps it hot. Simple, isn't it?

In addition to this, our heater has the best points of the rest. Write for catalog.

Wm. Baragwanath & Son,
54 West Division St., Chicago, Ill., U. S. A.



Send for this Pamphlet on the Heating and Ventilation of Buildings.

It discusses the different Methods of Heating, the Value of Fresh Air, the Air Required for Breathing, the Moving of Air, the Advantages of Mechanical Ventilation, Heating and Ventilating Engineering, the different Mechanical Systems of Heating and Ventilating, the problem of Supplying Heat, Types of Ventilating Fans and Improvements in Fans and Air Heaters.

While the benefits arising from a well-designed mechanical heating and ventilating outfit are highly valuable and desirable and while poor ventilation is exceedingly expensive in both health and money, at the same time the warming and moving of air is far from costless and the proper designing of a heating and ventilating system requires a high-grade of engineering skill and experience. It is not usually advisable to adapt the plan of a building entirely to the system of heating and ventilating and at the same time it is often difficult to install the heating and ventilating system if no consideration has been given to it in planning the building. For this reason the building and the ventilating system should be developed concurrently and persons who are about to put in such plants should submit their plans to us before actually beginning work. Our advice will often save money or increase the efficiency of the plant.

We make it a point to see that our apparatus is put in under the best possible conditions and the user benefits by this policy as much as we do.

Ask for our Pamphlet "109P" and give the details of your requirements.

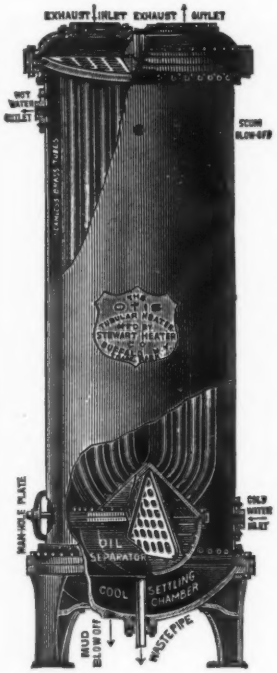
The Green Fuel Economizer Co.

MATTEAWAN, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green s Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 137

Why Permit Scale To Form?



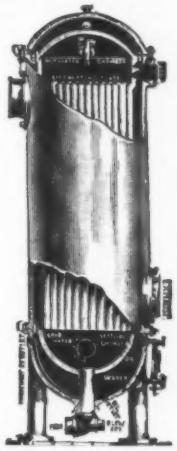
You may buy all the tube cleaners made and enough boiler compound to swamp your plant but, why do it when The Otis Feed Water Heater and Purifier costs less, does more and does it better?

Write for the Catalog.

THE STEWART HEATER COMPANY
45 E. DELAVAN AVENUE, BUFFALO, N. Y.

Riblet Feed Water Heater

Steam Area Three Times Area Of the Exhaust

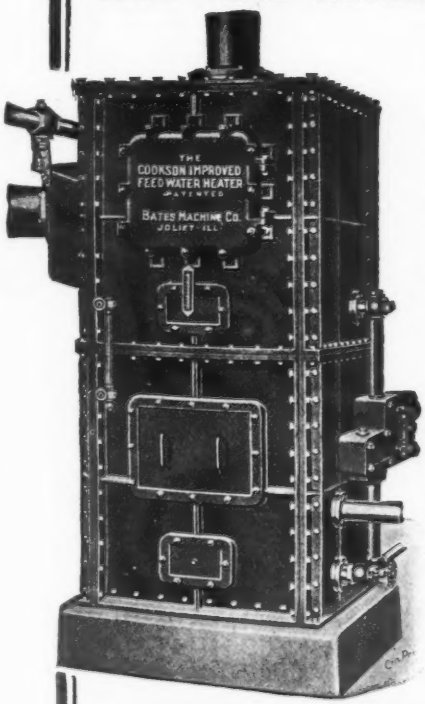


There is consequently no danger of back pressure.

A circulating plate fastened to the top tube plate insures uniform circulation through all tubes alike. Other facts on request.

Erie Manufacturing & Supply Co.,
1203 PEACH STREET, ERIE, PA.

COOKSON STANDARD ALL CAST IRON FEED WATER HEATERS



Highest Temperature and Positive Purification of feed water.

Perfect Separation and Removal of Oil.

Automatic Control of Cold Water Supply.

Dry Steam for Heating Purposes.

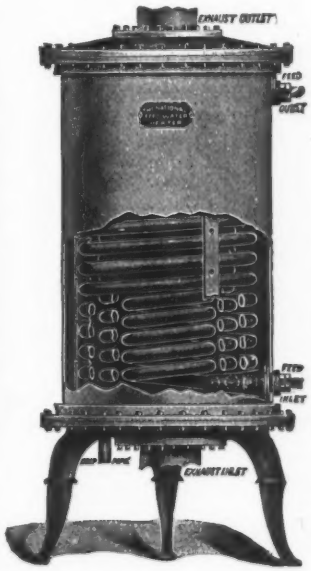
Finest Grade Special Fittings.

Lime Catching Pans. Especially Adapted for use with Heating Systems, Dryers, Etc.

Write for our new Heater Catalog.

BATES MACHINE COMPANY
Sole Manufacturers **Joliet, Illinois**

SEE THOSE COILS?



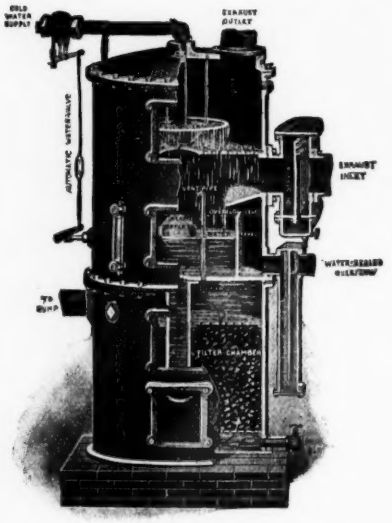
You don't see any inside joints or straight tubes to leak. No contact of the water with shell. No back pressure. No freak features. Nothing complicated to get out of order.

Nearly a million H. P. NATIONAL FEED WATER HEATERS are in use today.

Write for Catalog.

THE NATIONAL PIPE BENDING COMPANY,
175 Lloyd Street, New Haven, Conn.
120 Liberty Street, New York. 54 High Street, Boston, Mass.

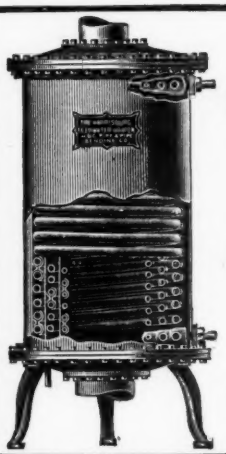
THE WHITLOCK OPEN EXHAUST
Feed Water Heater and Purifier



Perfect Oil Separation. Easily Cleaned. The Highest Possible Temperature in the Feed Water.

Manufactured by

THE WHITLOCK COIL PIPE COMPANY
HARTFORD, CONN.
New York Office—Singer Building, 85 Liberty Street.



HARRISBURG FEED WATER HEATER
of Pure Seamless Copper Coils

Guaranteed to be the most effective, most durable and cheapest heater manufactured.

COPPER, IRON AND BRASS PIPE

Coils and Bends of any desired shape. Manufacturers of High Grade Wrought Iron Pipe, Black or Galvanized. Write for descriptive catalog.

Manufactured by
The Harrisburg Pipe & Pipe Bending Co.
950 Herr Street, HARRISBURG, PA.

Every Coil a Spring

Reilly Multicoil
FEED WATER HEATER

IN AN ADVERTISEMENT we cannot describe all the advantages of this heater. We therefore ask you to write for our Catalog.

The GRISCOM SPENCER CO.
90 WEST ST., NEW YORK.

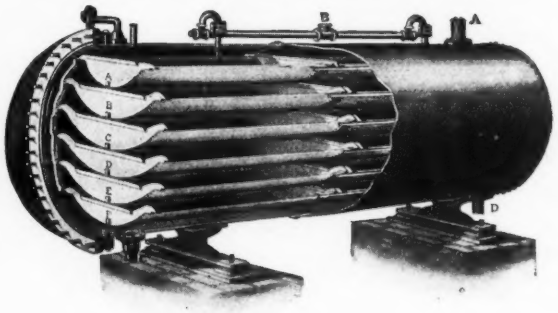
The Reilly Oil and Grease Exractor. | Agents: Russel Engines—Tudor Boilers
Mfgrs: Tanks—Special Machinery of all kinds

THE BEST WAY

TO KEEP BOILERS CLEAN IS TO PURIFY THE FEED-WATER. TO PURIFY THE FEED-WATER IS TO USE A

HOPPES LIVE STEAM FEED-WATER PURIFIER.

In Hoppes Live Steam Feed-Water Purifiers *no use is made of chemicals*, but the same principle is employed as in the Exhaust Steam Feed-Water Heater. The raw water is brought into *direct contact* with the live steam on the large heating and lime-catching surface of the pans. Its temperature is raised to almost that of steam in the boiler, and as in the Exhaust Steam Heater, the scale-making solids are precipitated and retained on the pans, but the purification is much more complete owing to the high temperature of the live steam. *No expense after installation* except for cleaning which is merely nominal. Write for particulars, prices and guarantee.



We also manufacture EXHAUST STEAM FEED-WATER HEATERS, STEAM SEPARATORS, OIL ELIMINATORS and EXHAUST HEADS.

CATALOG ON REQUEST

HOPPES MFG. CO., 19 Larch St., SPRINGFIELD, OHIO.

DO YOU KNOW OF ANY NON-CONDENSING PLANTS THAT SHOULD BE RUN CONDENSING?

We will send free the above Engineer's Sketch Book and Hand Book of Useful Information to any engineer who will tell us of some steam plant where the economy could be improved by the use of Wheeler Surface, Jet or Barometric Condensers, Wheeler-Edwards Air Pumps, Wheeler-Barnard Water Cooling Towers, or Wheeler Centrifugal Pumps, also of any plant where Triple Effect Distilling Apparatus, or other Vacuum Machinery may be needed.

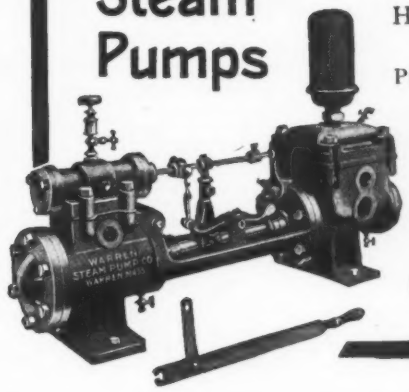
We have just begun the publication of a series of engineering bulletins treating on Steam Condensing and Vacuum Machinery, and we would be pleased to place your name on our mailing list in addition to sending you the above hand book. In writing, be sure to give us the full name and address of the plant mentioned and of the man to whom we should send our literature.

New York, Cincinnati, Chicago, Denver, Boston, Pittsburg, St. Louis, San Francisco, Atlanta, Houston, St. Paul.

(Builders of Wheeler Surface, Jet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery). 20

WHEELER
CONDENSER & ENGINEERING CO.
CARTERET, NEW JERSEY.

Steam Pumps



of the Highest Class.
Repairing of Pumps a specialty.
Send for Catalog.

Warren Steam Pump Co.,
Warren, Mass., U. S. A.

300° Is Too Hot For Scale

and it's just this excess over the ordinary heater temperature that makes the Eclipse a protection against scale. Write.

The Eclipse Feed Water Heater & Purifier Company, Oshkosh, Wisconsin.

Power Station Pumps and Condensers

Epping-Carpenter Co., - - Pittsburg, Pa.

Alberger Condenser Co.

Condensers, Cooling Towers, Vacuum Pumps, Heaters

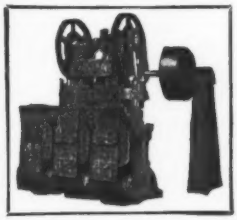
95 Liberty St. New York

Centrifugal, Volute, and Turbine Pumps

Alberger Pump Co.

Deming

Ask for Catalogue "G" and treatise "Feeding Boilers."

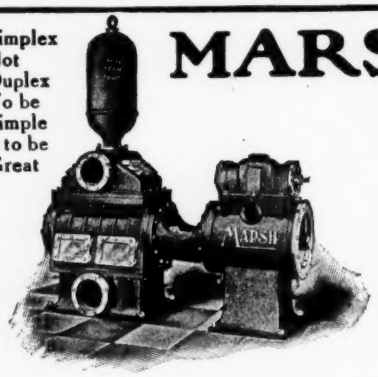


For any service. **Power**

For operation by any power. **Pumps**

The Deming Company
Agencies in Principal Cities
Salem, Ohio

Simplex Not Duplex To be Simple is to be Great



MARSH BOILER FEEDERS

are designed for handling hot as well as cold water. They are *at regular prices* fitted with bronze Piston Rods, bronze Water Cylinder Liners held in place by Studs, bronze Valve Seats, Stems, Nuts and glands. THE BEST OF MATERIAL AND THE BEST OF WORKMANSHIP ONLY GO INTO **MARSH PUMPS.**

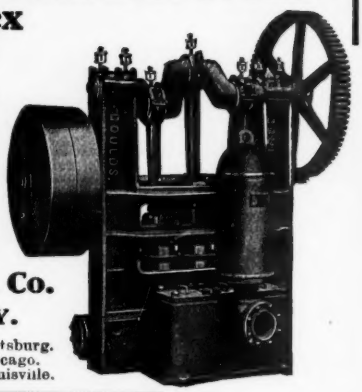
Write for Catalog 17-G.

American Steam Pump Co., **Battle Creek, Mich.**

The Many Installations of GOULDS Efficient Triplex Power Pumps

For Municipal Water Works
Boiler Feeding
Hydraulic Elevators
Mine Pumping
General Water Supply, Etc.

Have fully demonstrated their practicability and efficiency for these important services.

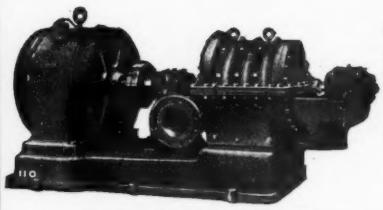


The Goulds Mfg. Co.

Seneca Falls, N. Y.

New York. Philadelphia. Pittsburg.
St. Louis. New Orleans. Chicago.
Los Angeles. San Francisco. Louisville.

DE LAVAL



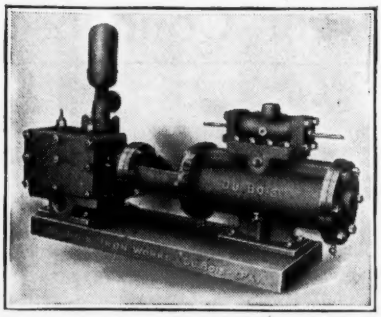
Steam Turbine Motors
Steam Turbine Dynamos
Steam Turbine Blowers
Steam Turbine Centrifugal Pumps
Electro Motor Centrifugal Pumps

Send for Catalog No. 20.

De Laval Multi-Stage Pump.

DE LAVAL STEAM TURBINE CO.,
Works and Sales Offices, TRENTON, N. J.

UNEQUALED



SIMPLICITY

DuBois Pumps

are entirely automatic in operation and are guaranteed to give perfect satisfaction.

We ship pumps on 30 days' trial and if unsatisfactory same may be returned at our expense. Purchaser takes no risks.

DU BOIS IRON WORKS
Established 1877
805 Brady Street **Dubois, Penna.**

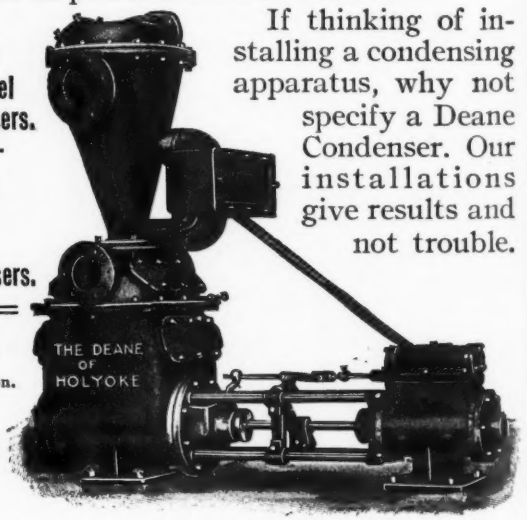
The Deane Independent Condensing Apparatus shown here, is one of the condensers which are today condensing steam from several thousand engines in power houses of all kinds.

If thinking of installing a condensing apparatus, why not specify a Deane Condenser. Our installations give results and not trouble.

Vertical Fly-Wheel Condensers.

Vertical Direct Acting Condensers.

PRICES furnished upon application.



MANUFACTURED BY

The Deane Steam Pump Co.
HOLYOKE, MASSACHUSETTS, U. S. A.

Warerooms:
BOSTON, 42 Batterymarch Street
NEW YORK, 115 Broadway
PHILADELPHIA, 724 Arch Street
CHICAGO, 770 Old Colony Building
ST. LOUIS, 605 Chemical Building

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS—MECHANICAL STOKERS

Barberton, Ohio — WORKS — Bayonne, N. J.

BRANCH OFFICES

Boston—Delta Building
Philadelphia—North American Building
San Francisco—99 First Street
Pittsburg—Farmers Deposit Nat. Bank Building
New Orleans—533 Baronne Street
Denver—435 Seventeenth Street
Salt Lake City—Atlas Block
Chicago—Marquette Building
Atlanta, Ga.—Candler Building
Cleveland—New England Building
Mexico City—7 Avenida Jurez
Havana, Cuba—116½ Calle de la Habana
Los Angeles—Trust Building
Cincinnati—Traction Building
Seattle—Mutual Life Building

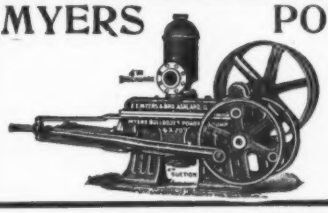
MORRIN CLIMAX BOILERS

More steam per pound of coal is generated by the Climax Boiler than by any other. It's the quickest-steaming, simplest and most economical steam generator going. Holds full pressure under all conditions and has nothing to cause trouble under expansion and contraction. Our booklet is waiting for your address.

THE MORRIN CLIMAX BOILER COMPANY, - BROOKLYN, N. Y., U. S. A.

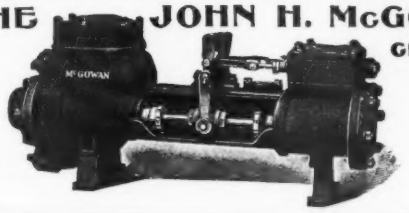
BURNHAM
STEAM PUMPS
ALSO
POWER PUMPS—AIR COMPRESSORS—CONDENSERS
UNION STEAM PUMP CO.,
BATTLE CREEK, MICHIGAN.

MYERS POWER PUMPS



Adapted especially for gas engines, motor and belt powers, in harmony with present requirements.
Catalog sent on request.
F. E. Myers & Bro.,
Ashland, Ohio, U. S. A.

THE JOHN H. McGOWAN CO.
Cincinnati, Ohio



Builders of
PUMPING MACHINERY
Single Duplex and Fly-Wheel Types
Water Works Pumping Engines

Dean Bros. Steam Pump Works
INDIANAPOLIS

Simple Plunger Pump

Simple and Duplex Boiler Feeders. Jet and Surface Condensers. Power and Electric Pumps.

Koerting
Exhauster & Pump Primer

These exhausters are used extensively for priming Centrifugal Pumps, Long Suction Pipes, Air Vessels, etc., and with 30 ft. of water pressure will overcome a suction up to 25 ft. They have no moving parts; are absolutely reliable; simple manipulation; low in cost and high in efficiency. When writing for price state length and height suction pipe, time in which to be evacuated, and pressure water.

Write for Catalog 4-P.

SCHUTTE & KOERTING CO.
12th & Thompson Sts., PHILADELPHIA.
NEW YORK, 50 Church St. CHICAGO, Security Bldg.
BOSTON, 98 High St. PITTSBURG, Keenan Bldg.
O. C. Goeriz & Co., SAN FRANCISCO

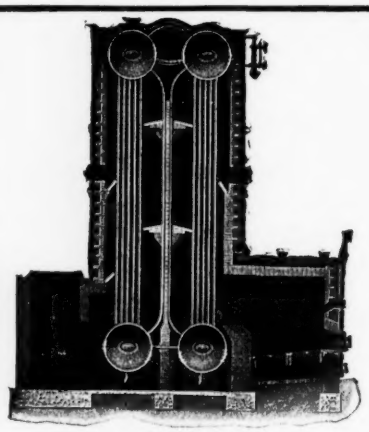
HEINE WATER TUBE BOILERS

AND SUPERHEATERS

All Flange Steel Construction

Send for { Boiler Logic and Superheater Logic

Heine Safety Boiler Co. 4210 Olive St., St. Louis, Mo.



TYPE B

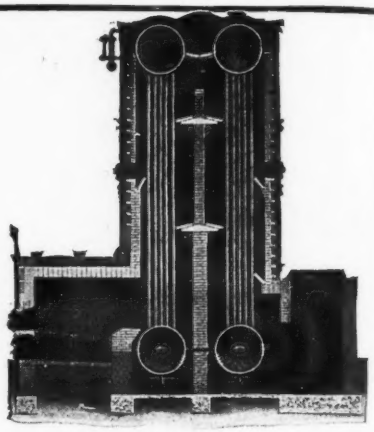
THE RUST
WATER TUBE
BOILER

SAFE, SIMPLE, DURABLE,
ECONOMICAL, ACCESSIBLE

Write for Report of Tests by William Kent.

THE RUST BOILER CO.,
PITTSBURGH, PENNA.

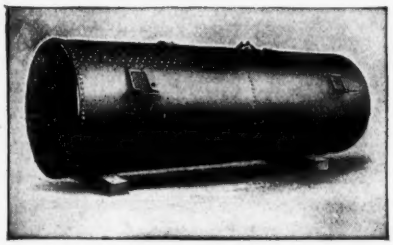
Branch Offices: New York, 50 Church Street; Birmingham, Alabama, First National Bank Building.



TYPE O

PARKER BOILER CO.
WATER TUBE BOILERS—SUPERHEATERS.
PHILADELPHIA, PENNA.
New York—Pittsburg—Chicago—Denver—San Francisco.

Foster Superheaters
Save feed water, condensing water, coal and boiler power.
POWER SPECIALTY CO.,
111 BROADWAY, NEW YORK.

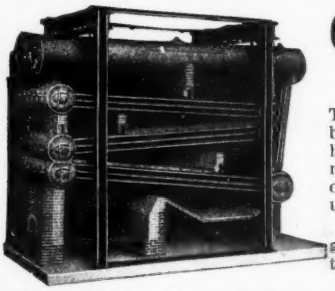


WICKES
Horizontal Tubular Steam Boilers
HIGHEST GRADE

THE WICKES BOILER CO.
Also Manufacturers of the Wickes Vertical Water Tube Safety Steam Boilers
Main Office and Works, Saginaw, Mich.

SALES OFFICES:
1411 West St. B'ld'g., West and Cedar Sts., New York City.
1139 AmericanTrust B'ld'g., Chicago, Ill.
Penobscot B'ld'g., Detroit, Mich. Empire B'ld'g., Pittsburg, Pa.
801 Brown-Marx B'ld'g., Birmingham, Ala.

WE HAVE NO USE FOR CAST IRON

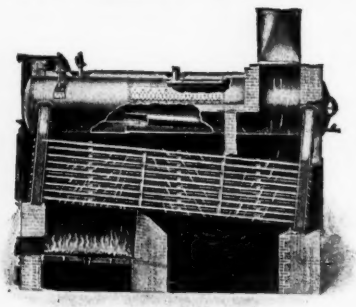


In making the Vogt Water Tube Boiler, we use only the best steel. Even the man-hole and hand-hole covers are made of pressed steel—not one pound of cast iron being used.

The triple pass through the gases is a feature worth investigating. Write for circular.

HENRY VOGT MACHINE CO., INC.,
LOUISVILLE, KY.

Water Tube Boilers



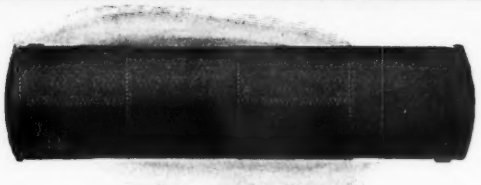
All Wrought Steel Construction

Ask for New Catalog P. W.

ESTABLISHED 1865.

E. KEELER CO.
Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.



KEWANEE TANKS

We are the largest and best manufacturers of storage and pressure tanks in the United States. The story is told. See Book No. 51. Send your specifications.

KEWANEE BOILER COMPANY
KEWANEE, ILLINOIS.

Edge Moor Boilers
WATER TUBE
EDGE MOOR IRON CO., Edge Moor, Delaware

Results of 27 years' Boiler Making Experience

Send for Catalog S.

Robb-Mumford Boiler Co.

Successors to Edward Kendall & Sons, Charles River Iron Works.

MANUFACTURERS OF THE

Robb-Mumford Internally Fired Boiler, Water Tube, Return Tubular, and other types of boilers; Smoke Stacks, Tanks, etc.

Works: South Framingham, Mass.

Sales Office: 131 State St., Boston.

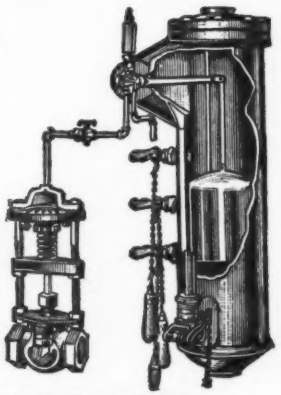
New York Office: 90 West St.

If You're Too Busy

to waste time watching the pressure, you need a **FISHER PUMP GOVERNOR.** It will do the watching better than you could even if you made that your sole business. *Ask us why.*

The Fisher Governor Co.,
Marshalltown, Iowa.

THE
BERRY
Safety Automatic
Feed Water
REGULATOR



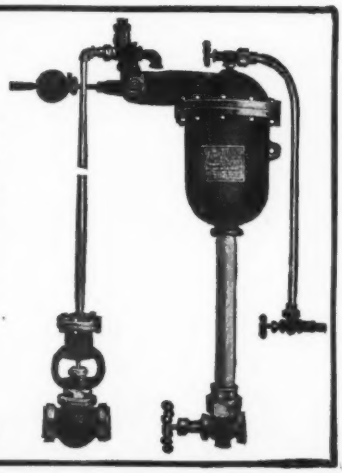
Send for Catalogue

BERRY ENGINEERING COMPANY
Chester, Penn.

Metropolitan Office, 136 Liberty St., New York City.

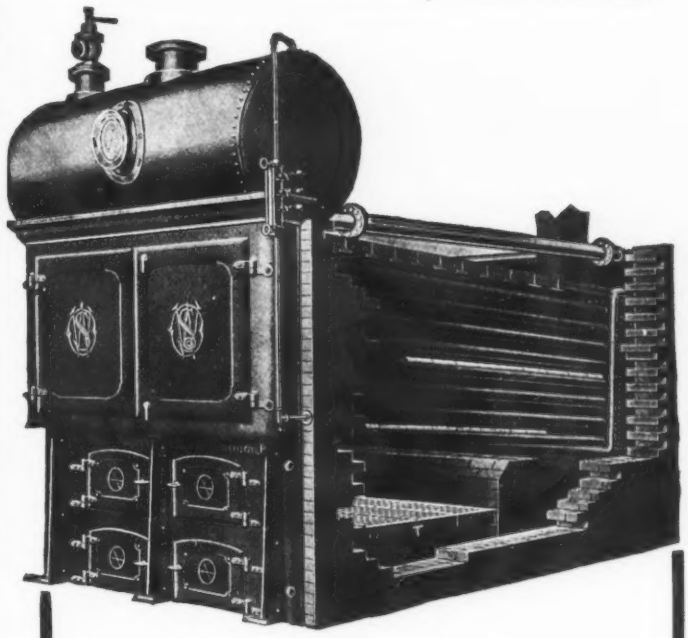
The Vigilant Feed Water Regulator

for Steam Boilers was the first in the field, and has the longest and best record of any of these devices. *Costs less to operate and maintain.* Constructed on a different and better principle than any other. Investigate it and the FULTON PUMP GOVERNOR, and send for latest catalog with list of users. A guarantee from a responsible firm with every machine.



THE CHAPLIN-FULTON MFG. CO.,
PITTSBURG, - PA.

D. W. Patterson, Agent, Harrison Bld., Philadelphia, Pa.



The Basis Of Economy

in any power plant is the boiler system. If you appreciate that fact you will do well to investigate

Our Safety Water Tube Boiler

Built for any pressure from 125 to 300 pounds. Meets all the high duty requirements of modern triple and quadruple expansion and compound engines. Perfect circulation, remarkable economy, and freedom to expand and contract, are features.

Ask for illustrated catalog and latest test report.

Oil Well Supply Co.,
Pittsburgh, Pa.

Boiler Works Dep't., - - OSWEGO, N. Y.

Branch Offices—NEW YORK, PHILADELPHIA.

We Want One Good Man

or firm in each city to push a GOOD STEAM SPECIALTY.

Last December we began to advertise this device;

In January one of our agents sold $1,500 worth;

Sales have increased every month since then.

Even men entirely inexperienced in steam plant matters have been able to secure hearings and to sell. Every steam plant can use our device and owners and engineers admit its value and merit at first sight.

We have sold repeat orders to the United States Government, the Pennsylvania R. R. Co., the Baltimore & Ohio Railroad Co., the Clark Thread Co., and other discriminating buyers.

Boiler plant owners and operators buy this device when it is explained to them and afterwards they advise their friends to buy it. They are so well pleased with it that afterward they come back to the agent for other supplies. It helps the agent to build up his other business among first-class and large steam plants.

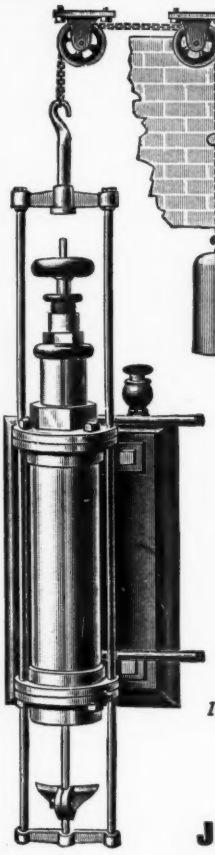
We are carrying on a vigorous advertising campaign and we supply agents with plenty of good advertising matter, catalogs, etc., with the agent's name imprinted thereon.

Remember, WE WANT JUST ONE ENTERPRISING MAN OR FIRM IN EACH DISTRICT.

17

Address, EUREKA,

Care of POWER, 505 Pearl Street, New York City.



Here is Another Curtis Specialty

The Curtis Damper Regulator

Is the most simple, durable and economical device on the market. Regulates to any position with the varying steam pressure—no water connection. It is fully up to the standard of other Curtis products.

IF YOU ARE NOT FAMILIAR WITH THEM WRITE FOR DESCRIPTIVE CATALOG.

Julian D'Este Company

24 Canal St., Boston, Mass.

Davis Pressure Regulators Save Steam

PRESSURE Balanced by WEIGHT

That's the simple and never failing principle upon which the Davis Pressure Regulator operates. It has no springs, toggles, diaphragm or auxiliary valves in its make up.

It accomplishes its purpose—the automatic reduction of pressure—by the most direct means and enables you to use steam at any pressure less than that of the boiler for auxiliary apparatus, heating, drying, cooking or any other purpose. When once set for a certain delivery, it automatically maintains that pressure constant regardless of boiler fluctuations.

Every Davis Pressure Regulator is backed with our positive guarantee to put a check on steam waste and to prove it we'll take all the chances. It has to make good, or it's your privilege to send it back at our expense. It's all we say it is, or the trial costs you nothing.

Everything for the Automatic Regulation of pressure is shown in our general catalog. Send for it.

G. M. Davis Regulator Co.

142 Milwaukee Ave., Chicago.

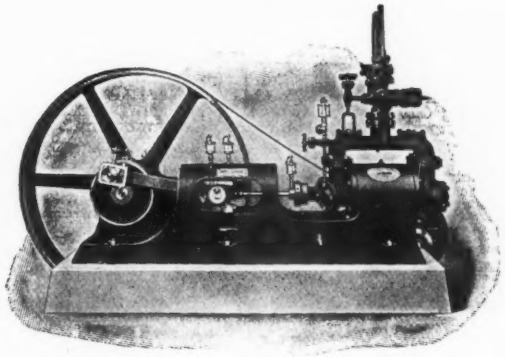
BRANCHES:
NEW YORK—123 Liberty St. PHILADELPHIA—56 N. 2nd St. BOSTON—104 High St. ST. LOUIS - 735 S Fourth St. SAN FRANCISCO — Metropolis Bank Bldg. PITTSBURG — 1206 Park Building.

"True In The Long Run."

"YOUNGER TRIUMPH"

A little duplicate of the regular Triumph compressor. Built to make only from 2 to 3½ tons of ice, it performs its work as economically as our 50 ton compressor. The Younger Triumph is "True In The Long Run."

Bulletin 502-C.



TRIUMPH ICE MACHINE CO.,
CINCINNATI, OHIO.

PRODUCER GAS

THE CHEAPEST POWER IN THE WORLD

GAS ENGINES, GAS PRODUCERS
COMPLETE PLANTS INSTALLED

BROOMELL, SCHMIDT & STEACY CO.,
YORK, PENNSYLVANIA.

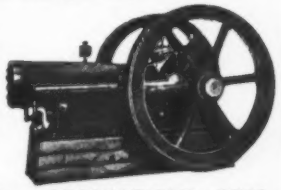
FOOS GAS AND GASOLINE ENGINES

HAVE WIPE SPARK IGNITER, positive acting and self cleaning.

VERTICAL VALVES, mechanically operated, admit fuel charge into cylinder at atmospheric pressure.

CENTER-LINE COUNTERBALANCING increases the efficiency and decreases the fuel bills.

ACCESSIBLE DESIGN makes it a simple matter to keep Foos Engines properly adjusted.



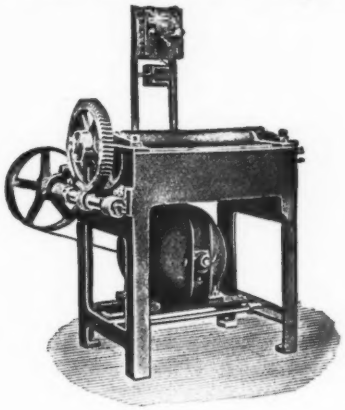
Get Catalog K.

THE FOOS GAS ENGINE CO., SPRINGFIELD, OHIO.

TRIUMPH MOTORS

For Service

Let us send you our booklet "The Way to Forget"



Stereotyper's Cylinder Shaver and Belted Motor.

TRIUMPH ELECTRIC CO.

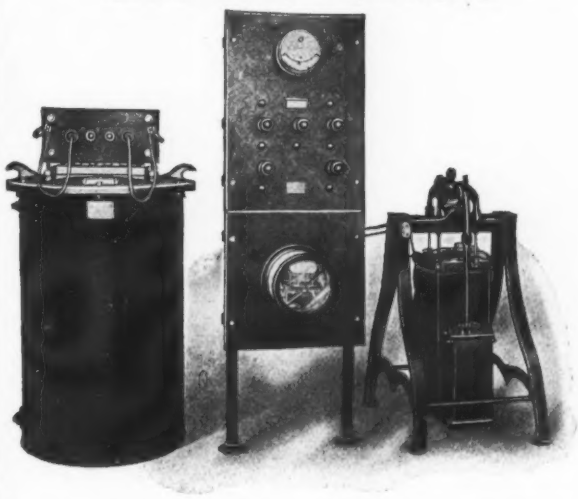
CINCINNATI, OHIO.

New York, 1 Madison Ave. Chicago, Great Northern Bldg.

FORT WAYNE ELECTRIC WORKS

The Working Parts

of Fort Wayne Series A. C. Arc Lighting Systems. They control the system automatically. They work together.



No other regulator operates on the same principle as the Fort Wayne regulator; the transformer is so designed that full load efficiency is maintained, regardless of actual load; Switchboard absolutely controls the circuit with no possible danger to the attendant. These facts explain the unusual success and superiority of Fort Wayne Series Lighting Systems. They are perfected systems. 735

Sales Offices | Main Office Fort Wayne, Ind. | In Most Large Cities

Southwark Foundry and Machine Co.,

PHILADELPHIA, PA.

SOLE BUILDERS OF THE

Porter-Allen Automatic Steam Engine,

the use of which insures a high economy in steam consumption and a minimum cost of maintenance.

The design is unsurpassed for simplicity and compactness, while the details of valves and gear, bed-plate construction, etc., are greatly liked by all users.

Adapted to every class of service.

ENGINE AND BOILER BARGAINS

ENGINES

20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
18 x 42 Hamilton Corliss	14 x 24 Atlas, Automatic
18 x 36 Wright, Corliss	13½ x 15 Taylor, Automatic
14 x 24 Wright, Corliss	12 x 18 Brownell, Automatic
12 x 24 Wetherill, Corliss	12 x 14 Green, Automatic
10 x 30 Hamilton, Corliss	12 x 12 N. Y. Safety, Automatic

Also large assortment of Automatic and Throttling Engines of other sizes.

BOILERS

84 x 18, 78 x 16, 72 x 18 High Pressure, 72 x 16, 66 x 16 and smaller sizes of Horizontal Tubular Boilers, also Vertical and Fire Box Boilers from 5 to 60 H. P.

Heaters, Pumps, Tanks, Saw Mills, Iron Working Tools, etc., etc.

Write for bargain list.

We are the sole manufacturers of the celebrated "Leader" Injectors and Jet Pumps.

THE RANDLE MACHINERY CO.
1768 Powers St., CINCINNATI, OHIO.

U.S. METAL POLISH
G. W. Hoffman, Sole Prop. 295 E. Wash. St.
INDIANAPOLIS, IND.
INFALLIBLE
FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc.
DIRECTIONS:
Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth
Economical
Durable
No Experiment
A Recognized Success

THE ONLY METAL POLISH

that works quick and easy and keeps its lustre. Holds old trade and makes new. IT DOES NOT DETERIORATE. Established 16 years.

3-Ounce Box for 10 cts. 5-Pound Pails, $1.00

Sold by Agents and Dealers all over the world. Ask or write for Free samples. Highest Award, Chicago, '93; St. Louis, '04.

GEO. W. HOFFMAN, Expert Polish Maker,
295 E. Washington St., INDIANAPOLIS, IND.
Branches—New York, Chicago, San Francisco.

MANGANESITE PASTE

(TRADE MARK REGISTERED)

A Superior NON-POISONOUS Jointing Material of Metallic Composition; for FLANGE and SCREW-JOINTS of every description on Steam, Water, Air, Gas, Ammonia, etc. UNITES TWO METALS AS ONE. Cheaper, more efficient than red lead—no waste in its use.

WALCH & WYETH, 87 Lake St., CHICAGO.

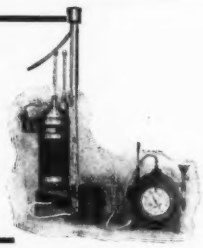
Manufacturers of the Erwood Straightway Swing Gate Valve. Many valuable features in one valve. Write for Catalog.

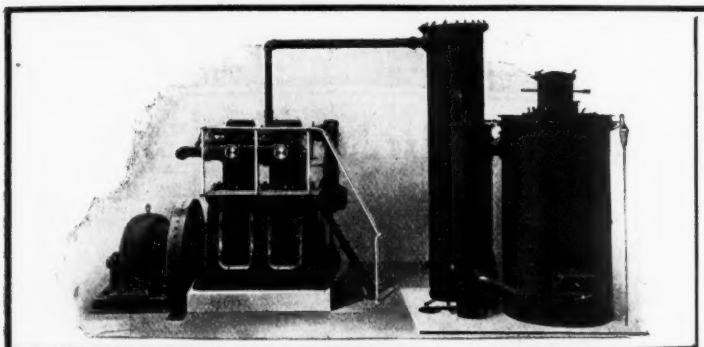
ECONOMY IS BASED ON FACTS

You should always know the heat value of the gas you use.
The Sargent Gas Calorimeter is as essential to the Gas Engineer as the indicator is to the Steam Engineer.
It is accurate, is the very best of construction, and saves the operator 50% of his time.

Write for Catalog and "Testing of Inflammable Gases" Booklet

SARGENT STEAM METER CO., 271-285 E. Madison St., Chicago, Ill.





WARREN GAS ENGINES
AND
SUCTION GAS PRODUCERS

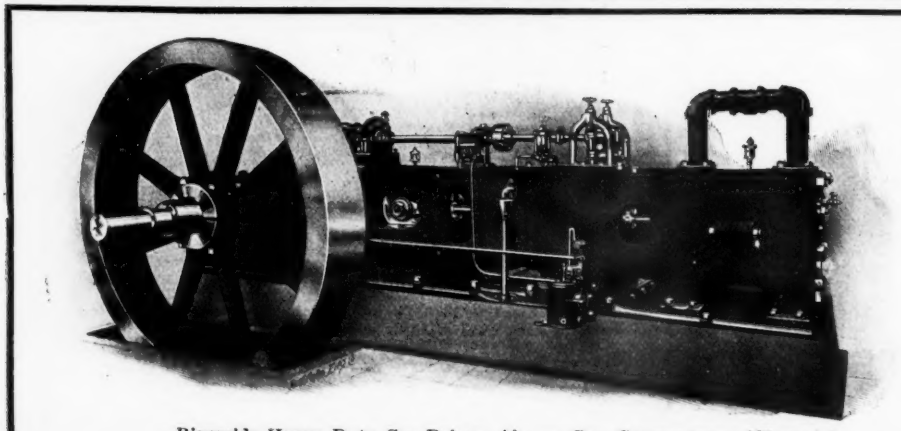
SATISFACTORY AND CONTINUOUS SERVICE
REGULATION AND ECONOMY GUARANTEED

WORKING PARTS

FEW IN NUMBER
EASY OF ACCESS

ENGINES OF VERTICAL AND HORIZONTAL TYPES
75,000 HORSE POWER IN SUCCESSFUL OPERATION

STRUTHERS-WELLS COMPANY, - - - Warren, Penna.



Riverside Heavy Duty Gas Driven Air or Gas Compressor. (Class A.)

Not Made From Wash Drawings

The cuts we show are made from engines we have built and delivered to purchaser, and they are giving steam engine satisfaction at a fraction of the cost, some of them in twenty-four hours' service. The RIVERSIDE heavy duty gas engine, is wholly unlike any other and is built in twelve types and seventy-two sizes from 10 to 2500 H. P.

We also Build a Complete Line of Gas Driven Air and Gas Compressors

Riverside Engine Company, Oil City, Penna.

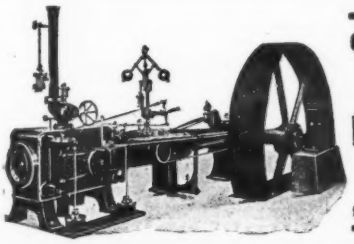
New York City, 50 Church St. Pittsburg, Keenan Bldg. Cleveland, Holbeck Co., 924 Rockefeller Bldg. Fitchburg, Mass., The Brown-Russell Co. Atlanta, The W. E. Austin Co., Candler Bldg. Philadelphia, W. P. Dallett, 49 No. 7th St. Indianapolis, Mr. F. Louis Egan, 1130 Congress Avenue.

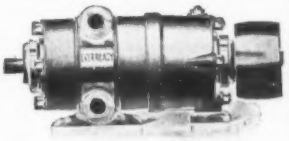
The Allan Metal
for Pistons and Bearings.
A. Allan & Son 482 Greenwich St. N.Y.

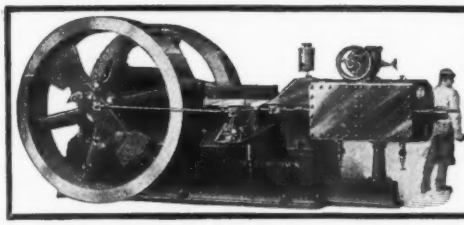
BALL ENGINES
Built only by
THE BALL ENGINE CO.
ERIE, PA.

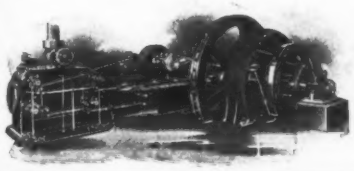
Shepherd Engines
Sold under a liberal and complete guarantee to the purchaser, covering **design, material, workmanship, efficiency, regulation** and **operation.**
SHEPHERD ENGINEERING CO., Williamsport, Pa.

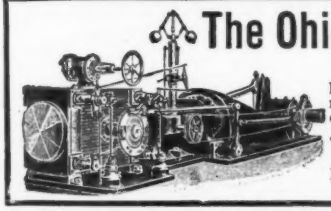
ANY SPEED FROM HIGH TO LOW—TRUMP ALWAYS
Northern motor drives insure a good play at all times—a handful of trump speeds for the operation of pumps, blowers, compressors, conveyors, etc. Means that each machine is driven at the speed best suited to its load for operating conditions. ¶Booklet S 9 will suggest some means of applying Northern motors in your work to assure maximum results.
NORTHERN ELECTRICAL MANUFACTURING CO., Madison, Wis., U. S. A.
Manufacturers of Standard and Special Electrical Machinery. 672

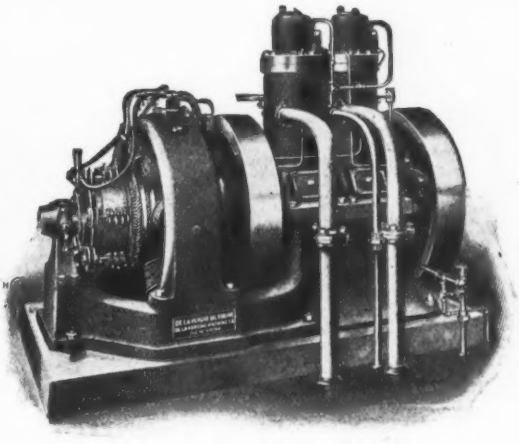

CORLISS ENGINES
Refrigerating and Ice Making Machinery
THE VILTER MFG. CO.
910 Clinton St., Milwaukee, Wis.

We Manufacture
AN ECONOMICAL AND DURABLE ROTARY ENGINE
Send for Catalogue.

Ball-Cooley Engineering Co.
316 HUDSON ST., NEW YORK CITY and 159 GREEN ST., BOSTON.


Good Engines
for every power purpose. Ask for Catalog.
Watertown Engine Co.,
Watertown, N. Y.


RICE & SARGENT
CORLISS ENGINES
For Reliability and Economy.
Built by
PROVIDENCE ENGINEERING WORKS,
Providence, Rhode Island.

The Ohio Corliss Engine

For hard work, heavy loads and high-speed, the Ohio shows close regulation and runs smoothly and quietly.
THE GRIFFITH & WEDGE CO.
Est. 1840. ZANESVILLE, OHIO

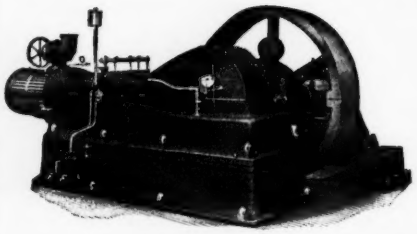


ALBERGER TANDEM GAS ENGINES
ACCURATE REGULATION FOR ELECTRIC SERVICE-AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR
A.H. ALBERGER COMPANY
45 TO 600 H.P. USING NATURAL GAS
85 TO 500 H.P. USING PRODUCER GAS
695-697 ELLICOTT SQ.
BUFFALO, N.Y.

York Manufacturing Co.
York, Pennsylvania

We manufacture all machinery and parts needed to equip a com lete Ice or Refrigerating plant—
Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings.
of all kinds. We employ over 1,250 men in the manufacture of Ice and Refrigerating Machinery exclusively. Catalogue sent upon request.

For small and medium sized plants our
OIL ENGINES
are cheaper, simpler. more compact than any other motive power. 8 H. P. hours per gallon of cheap oil.
5315 H.P. used by Baldwin Locomotive Works
The "De La Vergne" Vertical two-Cycle 4 to 25 H. P.
"Hornsby-Akroyd" Horizontal Four-Cycle 2 1-2 to 250 H. P.
DE LA VERGNE MACHINE CO.
Foot East 138th Street, NEW YORK.

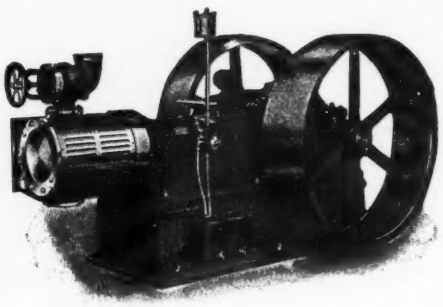


SIDE CRANK TYPE

Skinner Engines

CENTER CRANK
SIDE CRANK
SINGLE and FOUR VALVE

Skinner Engine Co.,
Erie, Pa.



CENTER CRANK TYPE

BUCKEYE ENGINE COMPANY,

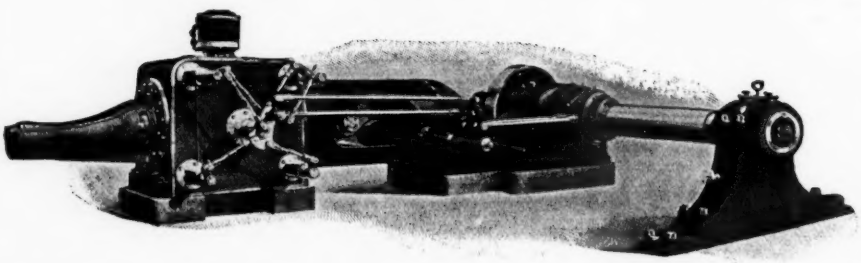
SALEM, OHIO

BUILDERS OF HIGH CLASS

STEAM AND GAS ENGINES

HIGH IN DUTY, SUPERIOR IN REGULATION
AND
ABSOLUTELY RELIABLE
CORRESPOND WITH US BEFORE PURCHASING
CATALOGS ON APPLICATION

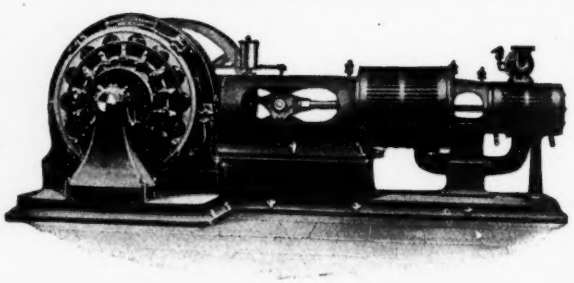
THE CLARK HEAVY DUTY CORLISS ENGINE



Valve travel never varies. No other Corliss engine has this advantage. Result perfect valve seats. Cuts off at all loads. As quick as the releasing gear. Heavy duty bed with bored guide. Main bearings half diameter of pistons. Length in proportion. Outboard bearing pedestal type. Adjustable in all directions. And self-oiling. Shaft swelled between bearings. Wheels above ten feet in diameter in halves. All wheels have split hubs. Our engines are unequaled for low steam consumption, perfect regulation, long life, nominal repairs, beauty of design. Perfect distribution of metal, high class material. Perfect workmanship.

THE CLARK BROS. CO., - Belmont, N. Y.

FOR ISOLATED ELECTRIC POWER HOUSES



Ridgway Dynamos and Engines are superior to all others in that they rarely require repairs of any kind and seldom if ever require repairs which necessitate sending parts to the factory.

Being built to run together they are more economical than would be possible to any other combination. *Write For Full Details.*

Ridgway Dynamo & Engine Company, **WORKS:** **Ridgway, Pa.**

Robt. Wetherill & Co., Inc.

CHESTER, PENNSYLVANIA.

CORLISS STEAM ENGINES

Manufacturers

POWER PLANTS BOILERS

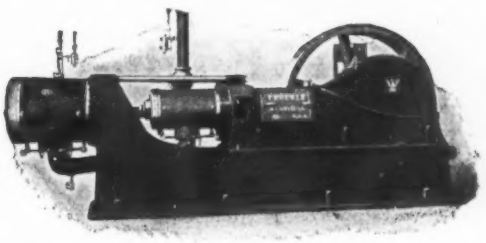
Phoenix Iron Works Company

BUILDERS OF

AUTOMATIC CUT-OFF ENGINES

ALSO

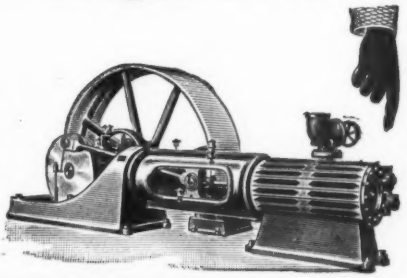
BOILERS, HEATERS, TANKS AND GAS CONDENSERS



General Offices and Works: - - MEADVILLE, PA.

No Matter How High The Steam Pressure

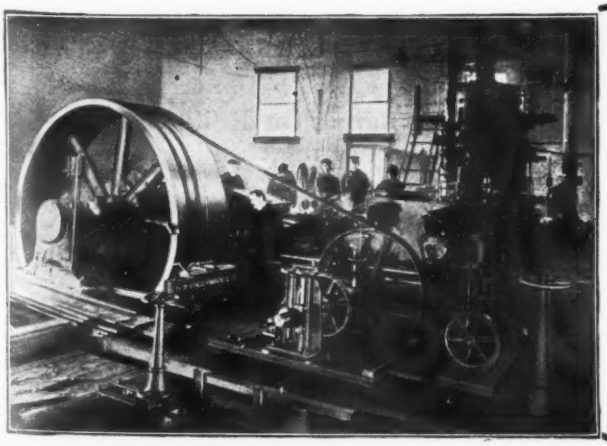
Fitchburg piston valves being perfectly balanced give exactly as good results as if the pressure were low.



Twenty hours in twenty years is enough time to keep our engine steam tight. Ask for other details. Write today.

FITCHBURG STEAM ENGINE COMPANY, Fitchburg, Mass.

E. H. Ludeman & Co., 165 Broadway, New York. H. J. Gebhardt, 1419 Fisher Building, Chicago.
Geo. H. Conner, 509 Mutual Life Building, Philadelphia. Western Trading Co., San Francisco. W. C. Teas, Chattanooga, Tennessee.



When You Want a Thing Well Done Get Some One Who Knows How

and have the work done in your own shop where you can see that it is well done. Send for us and the work will be done better, more quickly and at a lower cost than would be possible without us.

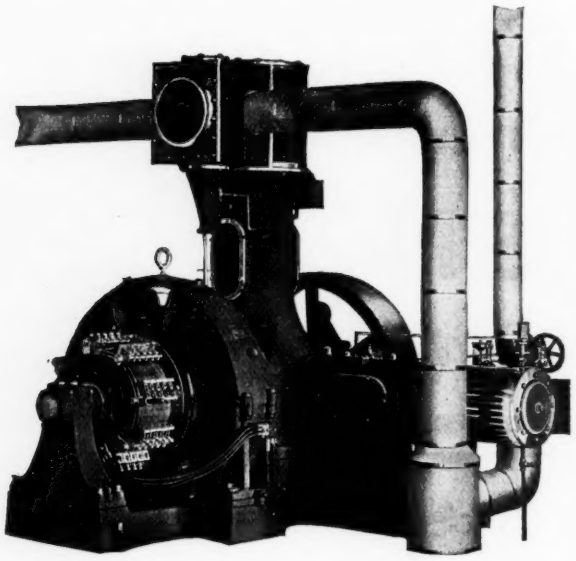
AMMONIA CYLINDERS INDICATED

"Useful Hints P" Sent to Engineers upon Request.

H. B. UNDERWOOD & COMPANY

ESTABLISHED 1870

1021 Hamilton Street PHILADELPHIA, PA., U.S.A.



The Engine For Driving Alternators

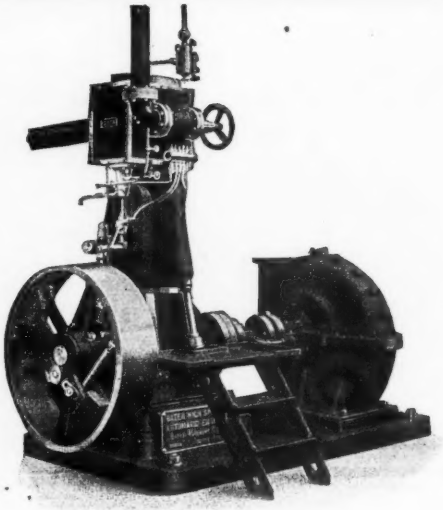
Where two alternating current electrical generators are run in parallel, their efficiency and regulation depend upon other things than the generators themselves. If the two generators are driven by engines of different types, or even by two ordinary engines of the same size and type but with the piston not moving in unison, cross-currents are set up, which waste power, reduce the capacity of the generator and interfere with the voltage regulation.

The desirable condition, therefore, in alternator driving is to have the turning moment of the prime mover absolutely uniform throughout a revolution. This can be attained, together with perfect conditions for balancing and high steam economy and in the least possible space, by setting the cylinders at right angles, so that the greatest effort of the one occurs at the time of the least effort of the other, resulting in a practically uniform turning moment throughout the revolution.

This is one of the advantages of the American-Ball Compound Engine. Other advantages realized at the same time are smooth, quiet running, small foundations and floor space and excellent regulation.

Write for our Bulletin 14.

American Engine Co.,
22 Raritan Ave., Bound Brook, N. J.
14



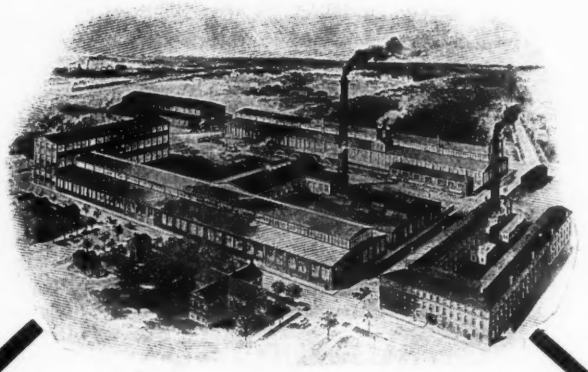
Bates Vertical Automatic High Speed Engine for connection to Pumps. Especially adapted for

WATER WORKS, IRRIGATION

and other places where it is desired to move a large volume of water at small expense.

CATALOG FOR THE ASKING.

BATES MACHINE CO., Joliet, Ill.



The Home Of The Cooper Corliss

We build engines for Rolling Mill, Railway, Lighting, and general Power Plant service.

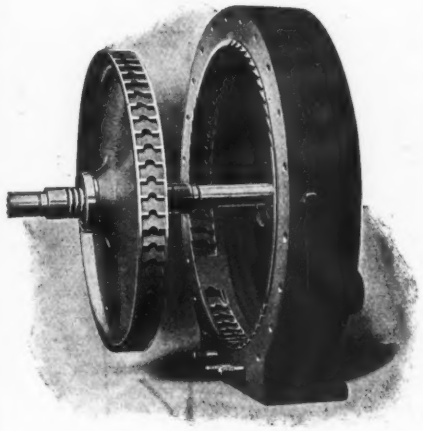
Complete Steam Plant Engineering a specialty.

THE C. & G. COOPER CO.,
MT. VERNON, OHIO.

New York, 11 Broadway. Boston, 411 Weld Bldg. Pittsburg, 604 Frick Bldg. Philadelphia, Drexel Bldg. Atlanta, 310 Candler Bldg., Charlotte, N. C., Court House Square. Chicago, 1539 First Nat'l Bank Bldg.

DO YOU KNOW THAT A

Sturtevant Steam Turbine



is just the thing for driving a

Mechanical Draft Fan?

Buckets Cut in Solid Steel.
No Noise.
No Vibration.
No Internal Lubrication.
No Oil in Exhaust Steam.

B. F. Sturtevant Company, Boston, Mass.

General Office and Works, Hyde Park, Mass.

NEW YORK PHILADELPHIA CHICAGO CINCINNATI LONDON

Designers and Builders of Heating, Ventilating, Drying and Mechanical Draft Apparatus; Fan Blowers and Exhausters, Rotary Blowers and Exhausters; Steam Engines, Electric Motors and Steam Turbines; Pneumatic Separators, Fuel Economizers, Forges, Exhaust Heads, Steam Traps, etc. 702

General Electric Company

Low Pressure Curtis Steam Turbines use steam otherwise wasted in exhaust.

The exhaust steam discarded as useless by reciprocating engines continues to do useful work in these turbines from exhaust pressure down to any available vacuum.

30% to 100%
is added to the station output without additional fuel

Low pressure Curtis Steam Turbine Generators are available in standard sizes from 300 kilowatts up. They possess the same characteristics of operation that have made the Curtis Steam Turbine the peer of prime movers.

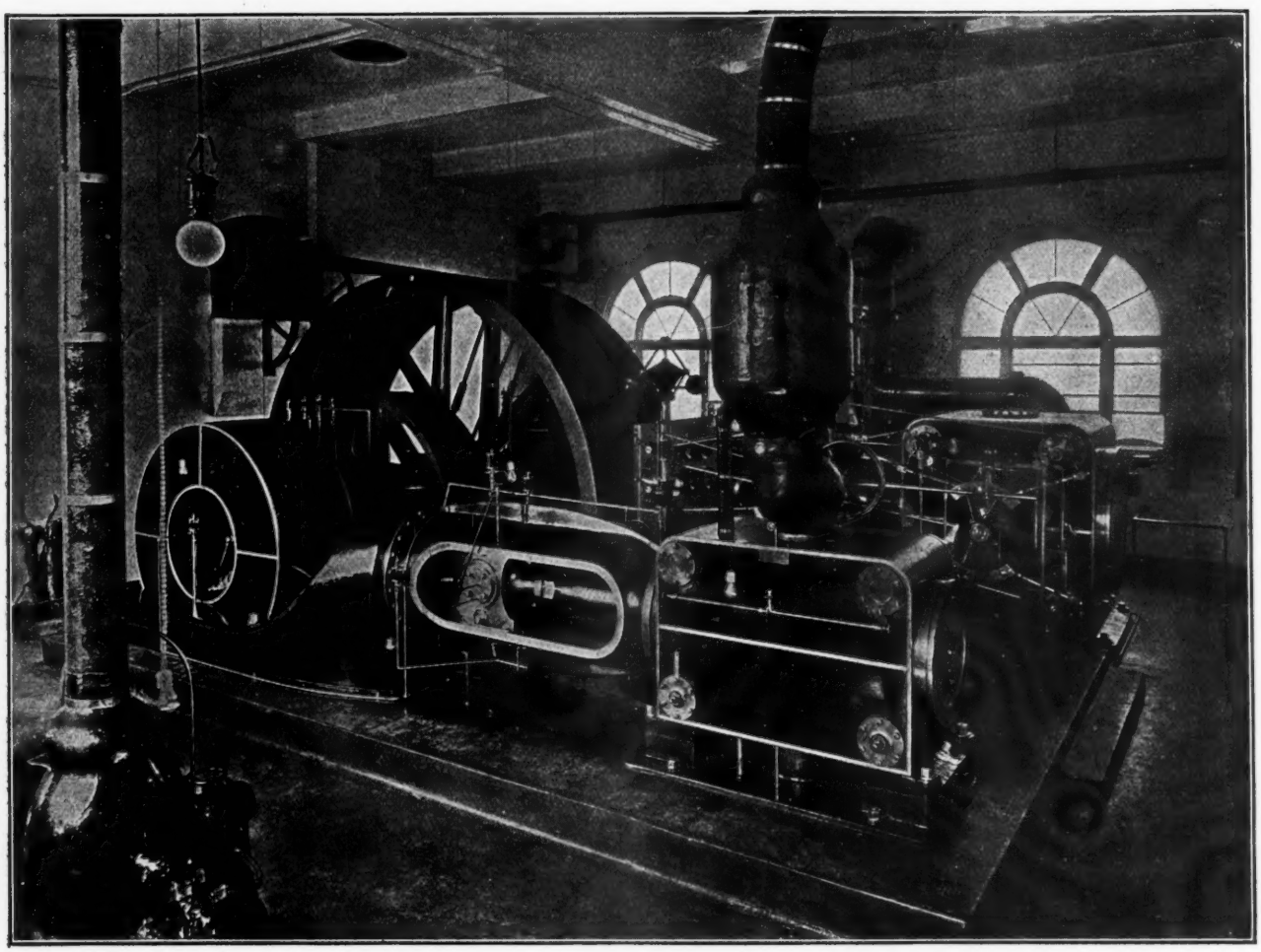
New York Office
30 Church Street

Principal Office
Schenectady, N. Y.

Sales Offices in all Large Cities

1918

Twin City CORLISS ENGINE



Large Cross Compound Twin City Corliss Engine running one of the largest Flour Mills in Minneapolis. 18 ft. fly wheel grooved for 24 2-in. ropes.

All auxiliaries driven by belt from main engine giving greatest possible economy in steam consumption.

Brochure No. 101 sent on application.

MINNEAPOLIS STEEL AND MACHINERY CO MINNEAPOLIS

There's No Oil On The Bearings! But There's Keystone Grease

and that means the bearings are running as nearly frictionless as it is possible to get them. KEYSTONE GREASE is "THE WORLD'S GREATEST LUBRICANT." It contains no fats, rosin, acid, talc, graphite, etc., and

It Lasts 50 Times As Long As Oil

KEYSTONE GREASE has a natural body that makes it lubricate until every particle is used up. It practically eliminates friction and thus saves from 25 to 75% in power, as well as greatly reducing repair bills. "KEYSTONE" is equally effective for heavy and light machinery, and is unaffected by heat and cold.

ASK US FOR A COPY OF THE BOOKLET, "GREASE vs. OIL"

KEYSTONE
TRADE MARK
REGISTERED U.S. PAT. OFF.

See Our Advertisement On Page 3.

KEYSTONE LUBRICATING COMPANY

Department B.

PHILADELPHIA, PA.

New England Office, 10 Oliver St., Boston, Mass.
Chicago Office, 1210 Tacoma Bldg.
Northwestern Office and Warehouse, 502 McPhee Building, Denver, Col.
New York City Office, 96 Warren Street.
Southern Office, 610 Chartres St., New Orleans, La.
San Francisco Office and Warehouse, 268 Market Street.

BRAIDED
ROUND AND SQUARE
FOR PISTON RODS
IN SIZES
1/4, 5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, 15/16, 1, 1 1/8, 1 1/4, 1 3/8, 1 1/2, 1 5/8, 1 3/4, 1 7/8, 2
and 2 inches.
In 5 Pound Boxes.

If your dealer does not carry Palmetto Packing in stock write us his name.

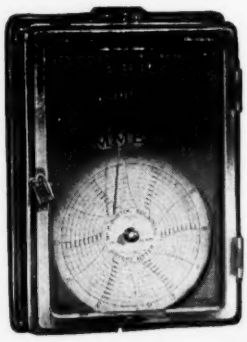
PALMETTO
PACKINGS

Let us send you free working samples to prove that Palmetto is the best high pressure steam packing on the market.

TWIST
FOR SMALL VALVES
Size, 1/16 inch 120 feet to pound
" 1/8 " 75 " "
" 1/4 " 50 " "
On 1 Pound Spools
In Individual Dust Proof Boxes.

GREENE, TWEED & CO.
SOLE MANUFACTURERS
109 DUANE ST., - - NEW YORK

THE BRISTOL COMPANY
SPECIALISTS IN
Recording Instruments
FOR
PRESSURE
TEMPERATURE
AND
ELECTRICITY



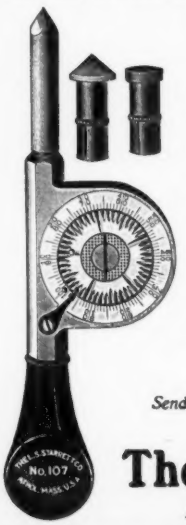
Wm. H Bristol Recording Shunt Ammeters
And
Bristol's Recording Pressure
And
Vacuum Gauges For Power Plants.

The BRISTOL CO., Waterbury, Conn.
BRANCH OFFICES
114 Liberty St., NEW YORK. 753 Monadnock Building, CHICAGO.

STARRETT
SPEED INDICATORS
OR REVOLUTION COUNTERS

No. 104.—This indicator may be run at the highest speed required without heating. The working parts are encased. Dial has two rows of figures, reading right or left as the shaft may run. Steel pointed spindle with rubber tips for both pointed and centered shafts. The (O) mark may be instantly set at starting point.

Price, Postpaid, $1.00



No. 107.—Has all the good points of the above, and in addition has a hard rubber handle for insulation when used on electrical machinery. It also automatically registers the number of revolutions up to 5,000, thus relieving the mind from keeping count.

Price, Postpaid, $3.00

Send for FREE Catalogue, No. 17-R, of Fine Tools.

The L. S. Starrett Co.
Athol, Mass., U. S. A.